Discovery

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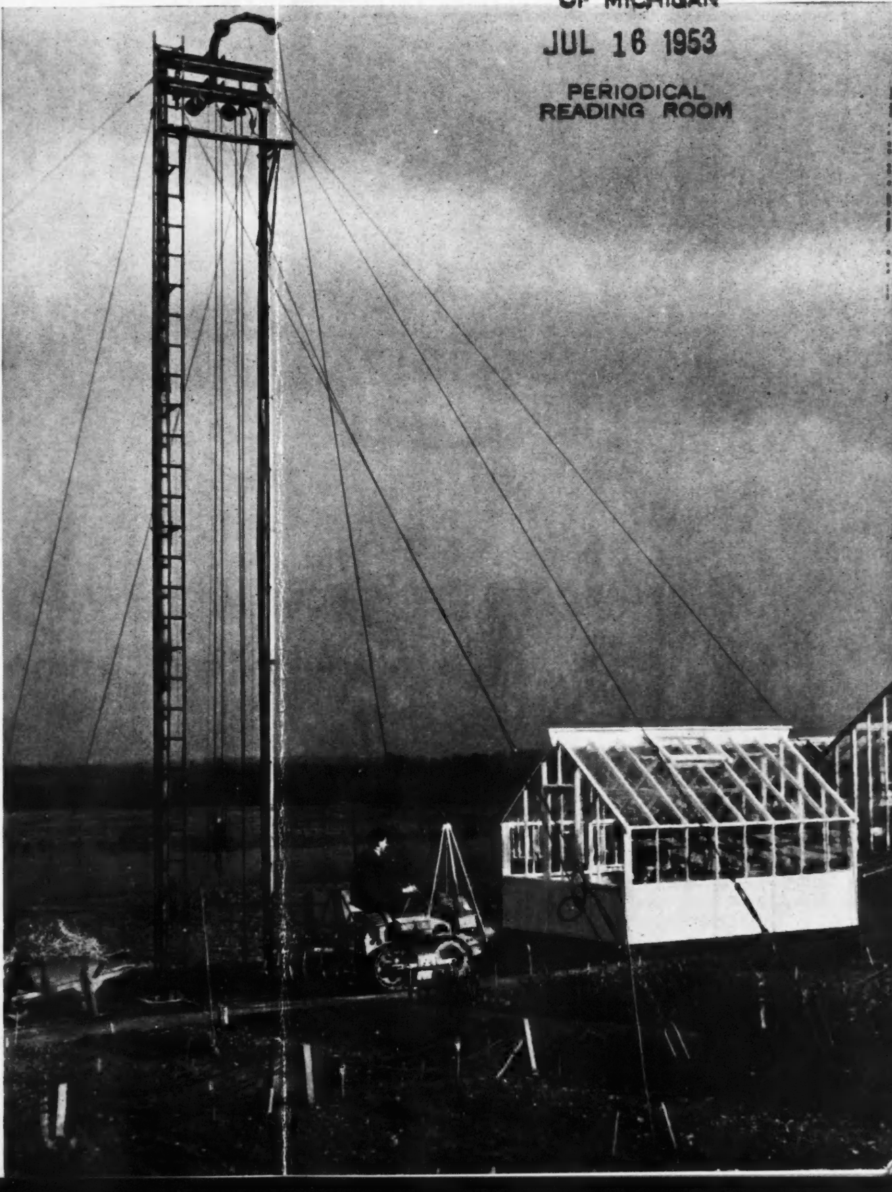

The electric tractor at the E.R.A. field station, Shinfield

Discovery

THE MAGAZINE OF SCIENTIFIC PROGRESS

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THE PROGRESS OF SCIENCE

PROTEIN FOOD FROM LEAVES

The old saying that "all flesh is grass" is still as true as it ever was, for ultimately all animal life depends upon the supply of complex substances synthesised by plants. The crop plants, and the domesticated animals which feed upon grass and other vegetable feeding-stuffs, are the source of most of the world's food, and this is likely to remain so for many years to come. There is in fact no process in sight which is likely to enable man to convert simple chemicals into complex compounds of nutritive value on a large scale, and there is no prospect that the human race could ever become completely independent of farm products.

This situation tends to be accepted by most biologists, and if you ask them how the world's food supplies can be increased they will talk about the importance of bringing the maximum amount of land into efficient agricultural production. Some of the most important things to consider then are the exploitation of artificial fertilisers to the full, the improvement of cultural techniques, and the ensuring of an adequate supply of water to farm crops, which in some cases give far higher yields when irrigation is used to augment the natural supply; then, too, there is the possible improvement of cultural techniques, the breeding of better varieties of economic plants, and the stepping up of the efficiency of disease control and pest control.

The biologist can see plenty of room for all-round improvements, and he can foresee that the world output of food could be increased several times without ever departing from conventional farming practices.

Non-biological scientists are perhaps rather more inclined to give more thought to the possibility of producing food by fundamentally new techniques designed to make man less dependent on the photosynthetic process carried out by green plants. There are two reasons why this should be so. Firstly, chemists and physicists are accustomed to seeing their ideas develop into factory processes, the efficiency of which are under more or less complete human control. The efficiency of many such processes is high indeed, in contrast to the relatively low efficiency with which green plants carry on photosynthesis. About 1% of the solar energy falling on plant leaves is utilised to energise photosynthesis, and there seems little prospect of increasing that efficiency. As Prof. F. G. Gregory told the British Association in 1950, "It appears that neither by varying the plant nor the fertility of the soil can the intrinsic efficiency of energy accumulation by green plants be greatly changed." On the other hand it must be realised that green plants are carrying out the synthesis of organic compounds which just cannot be synthesised on any useful scale in the laboratory. Purely synthetic food production on any considerable scale is beyond man's present powers. It should also be noticed that many processes devised by man to convert one form of energy into another do not achieve an efficiency far exceeding the efficiency of energy conversion involved in photosynthesis. Take the production of electricity from coal, its transmission into your drawing-room, and the conversion of the electricity into heat by means of an electric fire; only about 1% of the heat in the coal is made available in this method of space heating, so perhaps after all the green plant is not so inefficient an energy converter after all!

The rate at which the world's population is increasing makes it imperative, however, that every feasible method of producing food that scientists can devise ought to be thoroughly investigated in case it might be developed to the stage when it could usefully add to the world's food supplies.

One technique which was well worth investigating was the production of food yeast. This depends on the factory culture of the yeast known as *Torulopsis*, which is able to convert inorganic nitrogen into protein with great efficiency: thus 80% of the nitrogen supplied to the yeast in the form of ammonium sulphate appears as protein in the food yeast.

Under ideal conditions half a ton of Torulopsis can synthesise 51 tons of protein per day. This compares very favourably with the pound of meat which a fully grown

bullock weighing half a ton adds to its weight in a day. The equivalent yield from half a ton of soya beans (one of the best protein-producing plants) would be about 80 pounds.

There are today two factories in the British Commonwealth manufacturing food yeast, one in Jamaica and the other in S. Africa. The production cost is about 1*s.* 3*d.* a pound. It is not however to be regarded as a thoroughly satisfactory foodstuff in its own right; it is more suitable for use as a supplementary food for fortifying an otherwise inadequate diet—in other words it is to be regarded as a 'balancer meal' for human consumption.

The successful development of food yeast manufacture has brought one indirect benefit in that it has stimulated interest in finding new sources of protein-rich foodstuffs. The possibility of extracting leaf proteins and using them as food is one idea which is attracting attention, and it was well covered in a recent paper by N. W. Pirie, head of the biochemistry department of Rothamsted Experimental Station, to the Society of Chemical Industry.

The argument starts from the fact that leaves can contain a large amount of protein; young and vigorously growing leaves contain as much as 30–40% protein, while their fibre content is low. This protein becomes a potential foodstuff if it can be separated from the inedible surrounding material, and Mr. Pirie points out that separations not fundamentally different are performed even by primitive peoples when they separate peas from the shells. (Incidentally, it may be noted that peas and beans are important foodstuffs as protein is concentrated in these seeds—their average protein content is over 20%, and in the case of soya beans it is nearly 40%.)

At Rothamsted the protein fraction of such leaves has been extracted on an experimental scale. The leaves are first put through a mill which reduces them to pulp. This stage in the process can be performed quite efficiently, and Mr. Pirie finds that for the expenditure of 20 h.p. as much as 6 tons of succulent leaves can be ground up in an hour. The next step is to press the juice out of the pulp, and Mr. Pirie says that a satisfactory machine to carry out this process has still to be designed. The juice can be readily fractionated into two parts; one is fluid, and contains sugars, amino-acids and mineral salts; the other, solid fraction contains the leaf proteins, together with fats and starch. This protein material is suitable for feeding to pigs and chickens, and Mr. Pirie says there is every reason to think that it could be turned into acceptable human food. Its merits as protein have not been adequately tested but the amino-acid analyses suggest that leaf proteins would satisfy human nutritional requirements because those analyses resemble those of other proteins that are known to be satisfactory. He thinks that plant proteins are too readily branded as 'second-class protein' by nutritionists, and indeed he criticises the classification of protein into 'first-class' and 'second-class' categories, because it does not take into consideration the fact that the merit of a protein depends on the precise nutritional role that it is playing.

It is difficult, of course, at this stage to estimate the price at which leaf protein could be produced on a large scale. Mr. Pirie says the best estimate he can give is 1*s.* 6*d.* a pound, which is approximately the present factory price for food yeast. (By the time subsequent handling and distribution costs have been added, the market price would be two or three times that figure.)

This paper gives no very clear idea of what crop plants would form a suitable raw material for the leaf-protein extraction process. One senses that Mr. Pirie does not consider grass satisfactory, though this is one of the few crops which lends itself to exploitation on the 'cut-and-come-again' basis that seems to be an essential requirement. It is stipulated that farming to secure maximum yield of leaf would mean maintaining a nearly continuous green cover. Mr. Pirie evidently looks to the botanist and the plant breeder to produce the right kind of plant for his process, and indeed he provides a specification of what he requires: "The efficient plant will probably have thin leaves growing all the way up a succulent stem and forming a continuous mass several feet thick. This will ensure that little light reaches the ground where it is wasted, that as large a proportion of it as possible is stopped by photosynthetic rather than simply opaque structures, and that much of the leaf area is in that part of the total volume of the crop that is sheltered from full sunlight. The importance of this last factor depends on the observation, made on many different species, that shade-grown leaves have a higher protein content, under conditions otherwise the same, than well-lit leaves."

It is obvious that the efficiency of the technique of extracting the protein fraction is the all-important consideration, and one would imagine that the next thing that requires to be done is for the Agricultural Research Council or some such organisation to get a group of expert chemical engineers to investigate this point. The process has been carried out experimentally on a fairly big scale; if the efficiency of extraction attained in the experiments seems to be reasonably high, then the investigation should be carried a stage further and given a pilot plant trial.

REFERENCE

"Food and the Future: The Efficient Use of Sunlight for Food Production", by N. W. Pirie: *Chemistry and Industry*, May 9, 1953, p. 442.

THE BREEDING OF ATOMIC FUEL

The atomic pile that creates more fissile material than it uses has been the dream of many experts for a long time—so long in fact that it is now difficult to trace exactly who it was that first thought up the concept of the breeder pile. Among those who have pinned their faith on this type of pile has been Sir John Cockcroft, who has gone on record with the remark that "the main hopes of an economic nuclear power system rest in fact on a thorough-going application of the breeding principle". The importance of this principle he particularly stressed in his lecture just published in the *Proceedings of the Institution of Electrical Engineers* (Vol. 100, Pt. I, May 1953).

The Minister of Supply recently announced that an experimental breeder reactor was being constructed at Harwell to test the practicability of the breeding principle. At the same time he stated that a full-scale breeder pile was to be built in Cumberland, and the fact that the designing of this pile has been started without having to wait until the first pile is operating suggests that the British

experts felt reasonably certain that the breeding principle would work in practice. One could not help wondering, too, whether there had been a whisper that the Americans with their first experimental breeder reactor were close to making the breeding trick work.

Now we know the Americans have been successful. This was announced on 4 June by the chairman of the U.S. Atomic Energy Commission, Mr. Gordon Dean, who stated that the A.E.C.'s first breeder pile "is operating in such a way that it is burning up U235 and, in the process, is changing non-fissionable uranium (U238) into fissionable plutonium at a rate that is at least equal to the rate at which U235 is being consumed".

The achievement is an historic landmark in the development of atomic energy, comparable in importance with the establishing of the practicability of the self-sustaining chain reaction in December 1942. It must have been a proud day for one man in particular—W. H. Zinn, who was present the day the first atomic pile worked successfully, and who as director of the Argonne National Laboratory carried much of the responsibility for the experimental breeder project.

The pile which made the headlines last month has been in the news before, for it is this reactor which months ago was reported to be producing 250 kilowatts of electric power. In June 1951 it was nearing completion at the Arco Reactor Testing Station in Idaho, and according to the A.E.C. report issued the following month the Argonne National Laboratory had already begun installing the reactor core and controls.

The reactor core (reported to be about the size of a football) contains a high concentration of U235. When this primary fuel undergoes fission, 2·55 neutrons on the average are released for every U235 atom that splits. To maintain the chain reaction it is essential for an average of 1 out of every 2·55 neutrons to be absorbed into another U235 nucleus. To achieve a breeding effect at least one neutron on the average must find a billet in a U238 nucleus, the net result being the formation of a plutonium nucleus. In order to achieve this degree of efficiency in neutron absorption the reactor core is surrounded with a blanket of natural uranium, all of which is U238 apart from the small percentage (0·7) of U235 present.

It should be noted that the design of this pile includes no moderating element such as graphite to slow down the neutrons, though of course the speeds of the neutrons entering the blanket are lower than those in the centre of the core. The neutron flux in the core is terrific; the published figure is 650 million million neutrons per square inch per second.

If the breeding process could be made 100% efficient, all the U238 might be converted into fissile material, and the amount of power derived from a given mass of uranium might be increased by 140 times as compared with the energy derived from the U235 fraction. This ideal is never likely to be approached, but breeding will make the 'fuel' costs of atomic power generation very much lower.

Mr. Dean's statement (which was recorded most fully in the *Manchester Guardian* of 5 June) did of course leave a great deal unsaid. No hint has so far been given as to the rate at which plutonium builds up in the reactor. It is generally assumed that such a reactor will be run until a sufficient amount of plutonium has accumulated to make its extraction worthwhile. (The plutonium would then be used as fuel in another pile.) One of the great snags is of course the fact that unwanted fission products are also synthesised in the running of the reactor, and the ultra-rapid 'corrosion', due to radiation maintained in the centre of the pile, presents a very difficult problem to the design engineers.

The Americans will use the experience gained with their first breeder pile to build large-scale reactors to test the feasibility of economic nuclear power. There seems to be a distinct possibility that this stage in the development of atomic power may be carried through by American industrial firms, which are likely to be allowed to build their own nuclear reactors in the near future.

DENTAL DECAY: THE NEED FOR MORE RESEARCH

The dentist now has an imposing range of scientific aids at his disposal, and there is no doubt that the remedial techniques which he can apply can do much to preserve teeth which otherwise would decay years before their time. On the other hand, dentistry can show relatively little in the way of progress on the preventive side, and there seems to be a real lack of knowledge about the factors that control dental hygiene. These thoughts were prompted by the article by the dental health consultant to the World Health Organisation, Prof. Guttorm Toverud of Oslo, published in the May issue of *WHO Newsletter*. This article opens with the categorical and disturbing statement that "the dental health of most people in the world is poor", and proceeds to establish at once the fact that dental decay is a civilised disease. He quotes the case of primitive Greenlanders, where the figure for dental decay is 2–5% of the population, whereas in Denmark dental caries attacks almost 99%. But among those Greenlanders who live at trading stations and eat modern sophisticated foodstuffs imported from abroad, caries is found in more than 50%. From Africa he takes the case of the Masai in Kenya who are practically free from caries, whereas 93% of the children in the government schools in South Africa are affected.

In some areas of northern India, caries may attack only 25% of the population, while nearly 100% suffer from diseases of the periodontal tissue (i.e. diseases of the gum and the tissues fixing the root of the tooth in the bone socket). Even ten-year-old children have diseases of the gum to the extent of 75%. The rate in corresponding age groups in the U.S.A. may be around 50%.

If dental decay or periodontal disease is not treated at an early stage, the tooth will be lost. This may happen in fairly young age groups, as illustrated by the following figures:

During a medical survey in Newfoundland in 1945, it was found that 41% of 376 persons had lost all their teeth at the age of 16 or over. In New Zealand, 45% of young men called to the colours for service in the Second World War had artificial teeth and 21% were completely without teeth.

After stating that the causes of caries have not yet been

explored in detail, Prof. Toverud refers to several factors which it is known operate to produce cavities in teeth, First of all the enamel has to be damaged, and this can only be destroyed by an acid. The most serious acid is lactic acid, which is produced by micro-organisms which ferment carbohydrates lodged on the tooth surface after eating. Here Prof. Toverud puts the blame quite emphatically on sugar, which is most readily converted into acid. Most conclusive evidence of the harmful effect on teeth of high, and especially frequent, use of sugar is found in an elaborate Swedish study of about 600 inmates in a hospital for mental defectives. On the normal diet in the hospital the caries rate was very low, but, when sugar in sticky bread was given at meals, the caries figure increased. This increase was even greater when sticky sweets were given between meals. The amount of extra sugar taken between meals did not need to be very great in order to result in an increase in the number of cavities. When the additional sugar was withdrawn, conditions returned to those of the pre-experimental period after one year.

Prof. Toverud states that research has shown that the total amount of sugar eaten per day does not play as great a role as the *frequency* of taking it.

Brushing and rinsing of the teeth *shortly* after eating, and particularly after eating substances which contain sugar, is of great value. Studies have shown that only half the amount of caries may develop in cases when the teeth are brushed and rinsed within ten minutes after eating food or confectionery.

The reason why a few people do not get caries in spite of eating much sugar and not cleaning their teeth may be either the high resistance of their teeth, the special composition of the saliva ('the natural mouthwash') or changes in the bacterial flora.

The degree of resistance of the teeth depends on conditions of nutrition during the stages of development, i.e. during foetal life and childhood. A diet containing a liberal amount of minerals and vitamins, particularly vitamins A and D, will ensure the necessary mineralisation processes in a healthy individual.

The presence of a limited amount of fluorine in communal drinking water during the mineralisation period has proved to increase resistance resulting, in some cases, in a reduction of 50–60% of caries in children. The application of a fluoride solution to the teeth soon after they appear has also given good results.

In areas where famine and malnutrition occur, the most important factor in the prevention of periodontal disease is to improve the nutrition standards of the people. Except for vitamin C, the lack of which produces the 'scurvy gum', no specific dietary factor has been found to be conducive to the health of the periodontal tissue. An ordinary, adequate diet is always valuable in ensuring resistance of the tissue.

Practically all the points which Prof. Toverud develops in his article, with the exception of the point about fluorine, could have been made twenty-five years ago, and most of them were well established fifty years ago. It is to be hoped that research in the next quarter of a century will be able to solve many of the outstanding problems of dental health.

AN ELECTRONIC INTERPRETER

Science is an international activity, and to keep abreast of progress in his particular sector every scientist needs to be able to obtain translations of many research papers published in foreign languages. This need is not likely to disappear in the near future, for there is no immediate prospect of a lingua franca coming into universal use in the scientific world. Today many machines exist which are capable of carrying out the most complicated computations, so why not build a machine that can do translations? This idea has in fact already received a considerable amount of attention, and according to an article in *Industrial and Engineering Chemistry*, the use of an automatic electronic 'interpreter' for the translation of languages appears feasible, although no such device has yet been built.

A possible pattern for the electronic interpreter has already been devised. The 'eye' of the translator would probably be a scanner, similar to those which are used in television cameras. The scanner, which would be capable of distinguishing the printed letters of a foreign language or alphabet, would send electronic messages to a memory unit. The memory system, in which a vocabulary of foreign words would be stored, would compare the impulses with its storehouse of words. The translator would then convert the words to their equivalents in the investigator's language, and feed them to an electric typewriter, which would deliver the completed translation. The machine would probably have difficulty with such grammatical details as case, tense and plural endings, but the translation would be adequate for many purposes.

How the electronic translator would operate has been demonstrated in experiments which have been conducted by Professor James W. Perry, of the Massachusetts Institute of Technology. In his tests, which were designed to simulate the techniques of the machine, Professor Perry took individual words from technical books in Russian, and had them copied on separate sheets of paper. The sheets were shuffled in order to remove the words from any context. Each word was then translated and marked as to part of speech. Finally, the words were reassembled in their original order and the resulting crude translation was edited and evaluated by a person who was familiar with the subject matter but not familiar with Russian, and he found the translation readily understandable.

Machine translation has promise of attaining a high degree of practical usefulness, the article in *Industrial and Engineering Chemistry* indicates. "But before the electron tubes—or transistors—can be turned loose to chew their way through the pages of foreign journals, many pertinent problems must be unfolded. It is apparent that translations in elegant style can scarcely be expected. Equipment of great complexity and cost would be needed to cope with all the difficulties of case, gender, and the like. Literary versions, however, are not needed. The standards for a satisfactory translation depend on the use to which it is to be put, and the ease of attainment depends on the degree to which readily definable meaning characterises the words of the original language, and on how well its syntax can be reduced to precise rules. Just how much consideration must be paid to grammatical structure is a point under study at present."

THE STACK PROBLEM OF ATMOSPHERIC POLLUTION

PROFESSOR O. G. SUTTON

C.B.E., F.R.S., D.Sc.

Atmospheric pollution due to industrial chimneys still causes much damage, but this could be rapidly reduced by the application of existing scientific knowledge. The way wind disperses air-borne effluents and dilutes them to a harmless level has been studied as a problem in micrometeorology, and a useful theoretical explanation of the mechanism of dispersal —which scientists and technologists are beginning to call the "Sutton-Bosanquet theory"—has been worked out. The author of our article, whose appointment as the new director of the Met. Office we announced last month, is chairman of the Atmospheric Pollution Research Committee, the advisory body set up by the D.S.I.R.

The average scientist, and certainly the man-in-the-street, is inclined to regard meteorology simply as the science of forecasting weather. This view oversimplifies matters in two ways—first, weather forecasting, at present, is more of an art than a science, and second, there are many branches of meteorological science in which the analysis of movements of pressure systems plays no part. One of these is the investigation of physical processes near the ground, and among a host of applications the study of the dispersion of atmospheric pollutants is of prime importance.

Pollution of the air of this country arises mainly from two sources—domestic fires and industrial stacks. Little can be done to reduce the first of these except indirectly by encouraging a greater use of smokeless fuels and the installation of properly built fireplaces. The problem here is mainly that of weaning the Englishman from his traditional fire of raw coal and of educating him to a proper sense of responsibility for the state of the atmosphere in his neighbourhood. Less than two centuries ago it was the universal practice to throw household refuse (and even sewage) into the streets and the science of sanitation did not exist. A century hence, posterity may marvel equally at a generation which allowed refuse to be thrown, indiscriminately, into the air it breathed.

The second main source of pollution, the industrial stack, presents simultaneously more urgent problems and a better chance of overcoming them. The present century has seen not only a rapid multiplication of chemical plant but also the advent of the atomic furnace, or pile. The effluents from both of these present potential long- or short-term hazards to health. The British Isles lie in the main west-to-east track of the cyclonic depressions of the middle latitudes, so that we have a particularly 'well-ventilated' climate into which we have poured the waste products of the Industrial Revolution for well over a century. Every so often the natural ventilation of the atmosphere breaks down and the dangers of uncontrolled dispersal of matter in the air become painfully evident. The London fogs of last winter are a perfect example. There is no reason to believe that anything unusually noxious was emitted at that time, but what was there did not disperse as freely as usual.

Normally, the ventilating power of the atmosphere is so great that a high stack is a safe and easy way of getting rid of smoke. Ideally, no noxious substance should be emitted in a highly populated area, but this, clearly, is impracticable. Instead, the problem of safeguarding the nation's health and of preserving the beauty of historic buildings must be approached by inquiring when it is likely to be dangerous to allow industrial smoke to escape in large amounts, and the first step must be an investigation into the mechanism of atmospheric diffusion and a realisation (if possible, quantitative) of the factors which control the spread of smoke from elevated sources.

DIFFUSION IN NATURAL WINDS

Fortunately, a substantial amount is known about atmospheric diffusion, although a complete theory of the process is still lacking. In brief, the spread of matter throughout the atmosphere depends chiefly on the *speed* and *turbulence* of the wind. The velocity of the wind is mainly, but not entirely, controlled by the prevailing large-scale pressure distribution, and in problems of diffusion wind speed enters as a simple dilution factor. The amount of turbulence, or unsteadiness, in the wind calls on more elaborate mathematics for its definition and, in addition, depends markedly on the time of day, state of sky and local topography. On a warm day of clear or slightly clouded skies the surface wind is highly turbulent and smoke diffuses rapidly, but on a clear night the position is reversed and gases and particles suspended in the atmosphere remain in high concentration for considerable periods. Diffusion (as measured by the spread of a cloud in a given period) can be from a hundred to a thousand times greater in strong sunshine than after dark. This is because sunshine promotes convection currents and general instability of the lower air layers, but at night a clear sky, by allowing terrestrial radiation to escape to space, brings about a very stable situation with relatively cold dense air blanketing the ground and damping out incipient convection currents. With overcast skies, diffusion is intermediate between these two extremes.

Thermal stratification of the lowest layers of the atmosphere thus causes a marked diurnal variation of diffusing power. Such effects are usually confined to the lowest few hundred feet and the stratification is essentially transient, the stable pattern of a clear night giving place to the daytime turbulent pattern within an hour or so of dawn. Usually, pollution which has accumulated overnight in the air near an industrial centre is rapidly dispersed by the morning sun. Occasionally, however, much deeper layers of stable air are produced by large-scale motions, for example, in a winter anticyclone. Such conditions may persist for days and often are accompanied by low temperature and high humidity. In these circumstances dense, dirty fogs (smogs) tend to form and persist near large towns and in industrial valleys, with the result that the weaker

members of a community, especially those liable to attacks of asthma or suffering from lung complaints, fall ill, perhaps to succumb in numbers which are large enough to attract public attention (for a few days at least) to the problem.

CHARACTERISTIC FEATURES OF STACK POLLUTION

Diffusion in a turbulent air stream is of the type known as *non-Fickian*, that is, the process cannot be related to a single constant coefficient of diffusion. In the atmospheric problem additional complications are introduced by the density changes noted above and by the 'roughness' of the ground. Despite these complexities, however, it has been found possible to make considerable progress by the methods of statistical hydrodynamics, with the result that atmospheric diffusion can now be related to a few simple quantities, the most important of which are the rate of change of wind speed with height, the gustiness or relative unsteadiness of the wind and a parameter specifying the roughness of the ground. For a given locality it is now possible to calculate, with tolerable accuracy, the spread of smoke from a known source by making use of special meteorological observations. (This is quite distinct from the problem of *forecasting* diffusion for a specific occasion, which must necessarily involve, among other things, a prediction of certain elements of weather.)

The problem thus amounts to an application of the theory of atmospheric diffusion to an elevated source. The broad features of the behaviour of a plume from a stack are shown in Fig. 1. At first, the smoke stays well above ground, but farther downwind the plume makes contact with the surface. The ground is impervious to most smokes, and in this way acts as a perfect 'reflector', so that the mathematical problem becomes that of calculating diffusion in a medium in which the effect of the boundary varies with distance from the source.

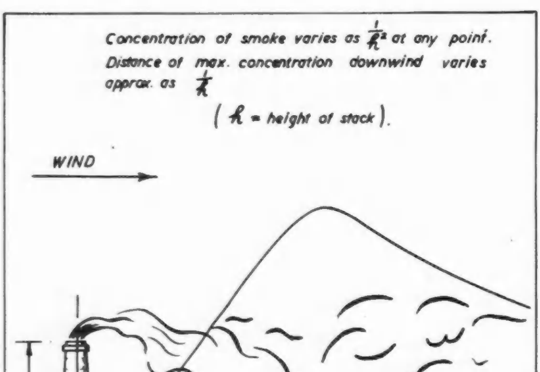

FIG. 1.

The theoretical solution, given by the writer (1947), is shown by the full line in Fig. 1. The concentration of smoke at ground level rises to a maximum value at a distance from the foot of the stack roughly proportional to the stack height, and afterwards it declines slowly to zero. The maximum value at ground level is directly proportional to the rate of emission and inversely proportional to the square of the height of the stack.*

The theoretical solution has been compared with observations by several workers. We give here the results of one such investigation, made by C. A. Gosline of the Du Pont Company (1952). The plant selected had an 80-ft. stack which projected 20 ft. above a peaked roof; the effluent contained nitrogen oxides and the terrain was flat and open. The *average* concentration measured at the selected site was 0·39 p.p.m.; the mathematical solution gave 0·36 p.p.m. as a weighted average.

The theoretical investigation brings out precisely the benefits to be gained from really high stacks, as shown by the inverse-square law, which is valid for all states of the atmosphere. The distance of the region of maximum concentration from the stack varies considerably with the degree of turbulence. In normal daytime conditions this distance is from 5 to 10 stack heights downwind, but in very stable conditions the plume may travel very far before smoke reaches the ground. At Brookhaven National Laboratory, U.S.A., a smoke plume emitted at 350 ft. above ground in very stable conditions has been followed for over 20 miles without measurable change in elevation or vertical dimension. This means that distant localities may be affected when the plume breaks up in the morning sun, although sites in the immediate vicinity of the plant may be free from pollution.

THE ADVANTAGES OF CONSERVING HEAT

In most cases, stack gases are considerably above air temperature at the orifice. It is important that this condition be maintained, so that the beneficial effect of natural convection can be realised to the full. This is well shown by an investigation made by Hill, Thomas and Abersold (1944) on pollution by SO_2 from a smelter at Murray, Utah. The stack height was increased from 200 to 455 ft., with beneficial results, but dilution of the stack gases by air brought in by a fan operating at the foot of the stack caused a reduction in the temperature difference between the effluent and the outside air, and the survey showed that concentrations a quarter to half a mile downwind of the stack were much higher with the fan operating than when it was not. Later, a coal-burning stack heater was placed at the base of the stack, giving a temperature difference of 165° F between the effluent and the ambient air (compared with 54° F difference with the fan operating). The resulting concentrations were found to be very small at all distances downwind.

The problem has been examined theoretically by the writer (1950) and by Bosanquet, Carey and Halton (1950). A plume of hot gas emitted in a side wind of speed u attains a height proportional to the strength of the source of heat Q and inversely proportional to u^3 before it

* The inverse-square law for the effect of stack height was first enunciated by C. H. Bosanquet and J. L. Pearson (1936).

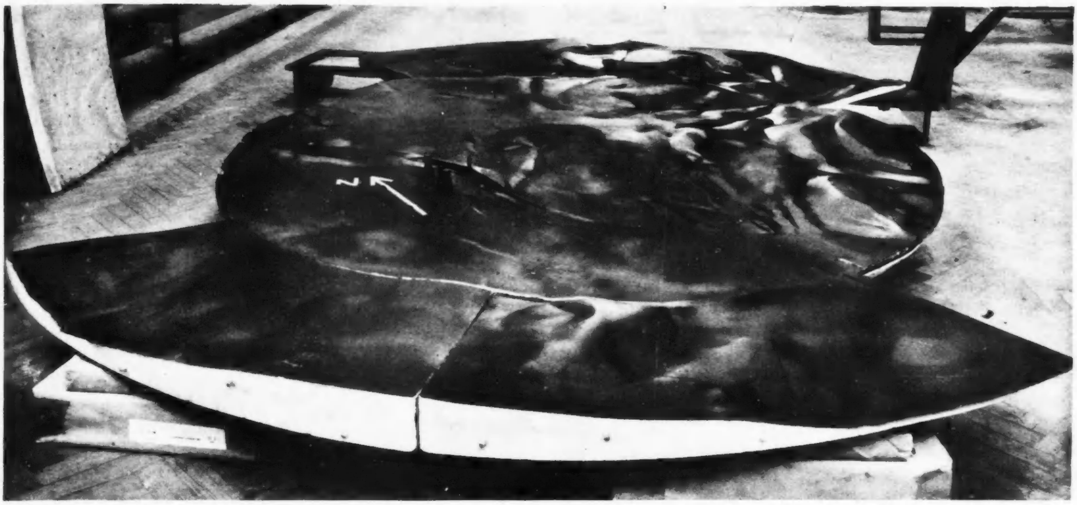

FIG. 2. The Neepsend Power Station model. (*Courtesy, the Director of the N.P.L. and the British Electricity Authority.*)

becomes horizontal. (The marked influence of the side wind in bending over the plume is seen in the familiar example of the guttering of a candle flame in a draught.) The effect on the ground is to decrease the concentration by an amount proportional to Q/u^3h, where h is the height of the stack. Hence for low stacks it is essential to conserve as much heat as possible. This effect may reduce the benefits to be gained by the removal of sulphur products by washing; a cool washed effluent will not necessarily yield low concentrations at ground level unless the efficiency of the washing process is high, and a partial washing of the gases may give higher concentrations than with unwashed gases.

MODEL INVESTIGATIONS

The calculations referred to above yield average concentrations over flat terrain, but in hilly or undulating country it is possible for local air currents to 'canalise' the pollution, and pockets of high concentration may form in valleys from purely dynamical causes. Such problems are not amenable to mathematical analysis. A method of investigating local effects has been developed by the Aerodynamics Division of the National Physical Laboratory. This begins with the construction of a relief map of the countryside around the stack, usually above 8 ft. in diameter, a size suitable for operation in the Open Jet Tunnel. (A photograph illustrating the use of this tunnel for this type of investigation appeared in DISCOVERY, January 1953, p. 5.)

The model can be used in two ways. If the surface is sprayed with white paint containing lead acetate, and air containing a small amount of hydrogen sulphide is discharged from the model stack, a rough estimate of the concentration can be made from the density of the brown stain on the surface of the model. This is a useful guide for later experiments and serves to show up any pockets which may form in the lee of hills. The behaviour of the stack plume is examined by photographing the white smoke obtained by atomising ordinary paraffin by electrically heated jets. The model used in the investigation of the Neepsend Power Station, near Sheffield, is shown in Fig. 2.

Model experiments can be of the greatest value to the designers of industrial plant by indicating the effects of surrounding buildings on the initial path of the plume. A massive structure upwind of a stack may produce local eddies which cause the smoke to be deflected downwards into neighbouring built-up areas. The rule usually followed is that originally suggested by Sir David Brunt, that the orifice of the stack should be not less than 2½ times the height of the surrounding buildings above roof level, and this seems to work well in practice. The golden rule for plant engineers should be "make the stack as tall as you can and conserve as much heat as possible", but considerations of pollution hazards should be borne in mind throughout the whole of the planning of a future power station or factory. This aspect often is lost sight of in the paramount claims of easy access, plentiful water supply and availability of labour.

METEOROLOGICAL CONTROL

The possibility of instituting some form of control on the emission, based on advice from the local meteorologist, has received relatively little attention so far, but there can be no doubt that this method of reducing hazards to life and property will have to be considered seriously in the future. There is one outstanding example of the successful application of meteorological control (1945). A zinc smelter situated at Trail, in the Columbia River Valley, caused such damage to vegetation in the state of Washington that an international tribunal was set up to examine the problem. This tribunal laid down maximum limits for the amount of sulphur emitted in relation to the time of day, state of crops (growing or non-growing) and degree of turbulence, the last named being measured by a specially designed bridled-cup anemometer, mounted on the stack and used as a gust integrator. This instrument records changes of wind speed of 2 m.p.h., and the degree of turbulence is specified as the number of such changes in

each half-hour. During the growing period the emission is stopped or heavily curtailed when the degree of turbulence is low, and this simple form of control seems to have worked satisfactorily.

One of the factors which hinders the widespread adoption of such control methods is the difficulty of forecasting conditions likely to produce high concentrations. Such forecasting is essentially local and demands long experience of a particular terrain. Some success has attended efforts to produce a forecasting method for Los Angeles, which suffers greatly from air pollution, mainly because of a peculiar meteorological situation.

To sum up, it may be said that considerable progress has been made towards a real understanding of the factors which control pollution from stacks, and there is no doubt that industry itself is anxious to assist in this work. The problem is not likely to become easier as time proceeds, because of the growing demand for more chemical products, many of which necessarily involve the disposal of substances dangerous to health. In a densely populated country such as ours there can be no relaxation of effort towards a cleaner atmosphere, not only for aesthetic reasons but because the health and well-being of the whole nation depend so much on an abundance of unpolluted air.

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FOREIGN ANIMALS ON BRITISH SHORES

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From time to time there are stranded on the shores of Britain, chiefly in the west, castaways from the ocean beyond. These castaways are organisms that differ greatly in habits, and often in structure, from the plants and animals which form the bulk of the flotsam and jetsam tossed up by the tide. Unlike the normal components of the drift, which are mainly bottom-living forms from the shore or from the sea-bed near by, the foreigners are at home only in surface waters far from land. There are a few species which with reasonable certainty can be expected to turn up sooner or later, more often in the west than in the east, and for which it is worth while keeping a sharp look-out, especially after onshore gales. Most of the likely species are shown in the photographic illustrations.

The underlying feature common to almost all these animals, which may differ so markedly anatomically one from another, is that they are forms which live right at the surface with part of the body—or the object to which they are attached—out of water exposed to the wind. Indeed it is the wind which is largely responsible for their stranding on our coasts. The Portuguese Man-of-war (*Physalia*) and the By-the-wind Sailor (*Velella*) carry above their gas-filled floats a sail, which the former can raise and lower, and even trim to the wind. Blown along by fair breezes, they trail their fiercely stinging tentacles through the water, and woe betide any fish which comes into contact with them. But in stormy weather they can only scud before the gale, and it is at such times that they may be blown on to a lee shore. In our part of the globe strong winds from the Atlantic are of common occurrence, and the ocean currents, too, are set mainly in our direction. Thus it is more to be wondered at that strandings of these creatures are relatively infrequent than that they should occur at all. The fact is that *Physalia* and *Velella* are natives of low latitudes, and it is only when uncommon combinations of winds, currents and other factors spread their shoals farther to the north-east than is usual that some reach the vicinity of the British Isles to be drifted ashore by purely local winds. The transparent papery supports of the float and sail of *Velella* are much more likely to be found than are the living animals, for they persist long after the brightly coloured tissues which clothed them have disappeared. When recording strandings of this organism the presence or absence of living tissues should be noted. The Portuguese Man-of-war is much less likely to be found; in the last hundred years on only three occasions (1862, 1912 and 1945) has it been recorded in large numbers aground on English shores, and always after strong and persistent westerly winds. At other times it has appeared in much smaller numbers, in most years not having been recorded at all.

Commoner than either of these are stalked barnacles. There are several species, but only two need concern us. The first is the Ships' Barnacle, which in these days of swift mechanically propelled vessels gets no chance to grow on hulls and is today largely confined to logs, bottles and other floating objects; just occasionally they establish themselves on sluggish vessels. It is no uncommon thing to find a stranded piece of timber festooned with these creatures, and we can be sure that such a log has drifted in from the ocean where it must have floated for a considerable length of time.

An allied barnacle, the Buoy-making Barnacle, has less need of a floating support. When very young, several of these animals will attach themselves to the same fragment of drifting seaweed, and as they grow larger and heavier they produce a stiff secretion full of gas bubbles which counteracts the increasing tendency to sink; thus the individual barnacles each contribute to the common float. This barnacle is a true oceanic surface-living species which not infrequently drifts ashore in the south-west; and sometimes in the north great numbers pass through the Faroe-Shetland Channel to enter the North Sea.

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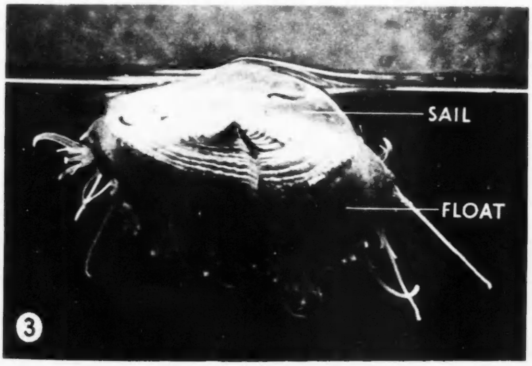


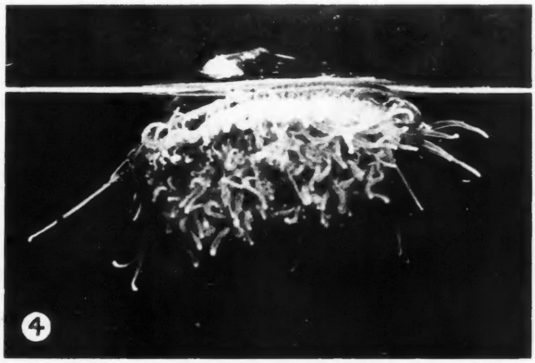
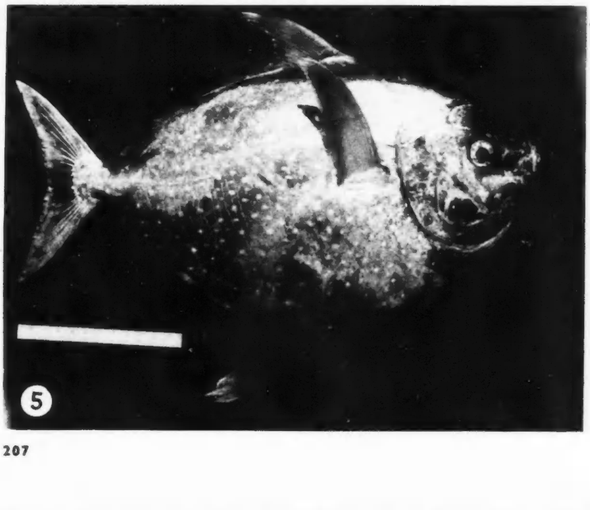


FIG. 1. The Portuguese Man-of-war (*Physalia physalis*) is a colony composed of polyps which are specialised in structure and function to serve the colony as a whole. The gas-filled float is one polyp, the long fishing tentacles are others. Yet other polyps eat the prey when caught and passed to them by the tentacles. Reproductive polyps are either male or female, both sexes occurring in the same colony. This organism stings fiercely and should be handled warily.

FIG. 2. A small fish has been caught and stung to death by tentacles of this specimen of *Physalia*.

FIGS. 3 and 4. Upper and lower sides of the By-the-wind Sailor (*Vellela spirans*) is also a colony of specialised polyps. There is one large feeding polyp placed centrally under the float; it is surrounded by reproductive polyps and an outer ring of stinging tentacular polyps, whose stings can also penetrate human skin. This particular specimen, photographed floating in a glass tank, is slightly damaged; it has heeled over against the side of the tank, and is not floating level as it would in nature.

FIG. 5. The Opah or Moon-fish. A foot rule alongside gives the scale.



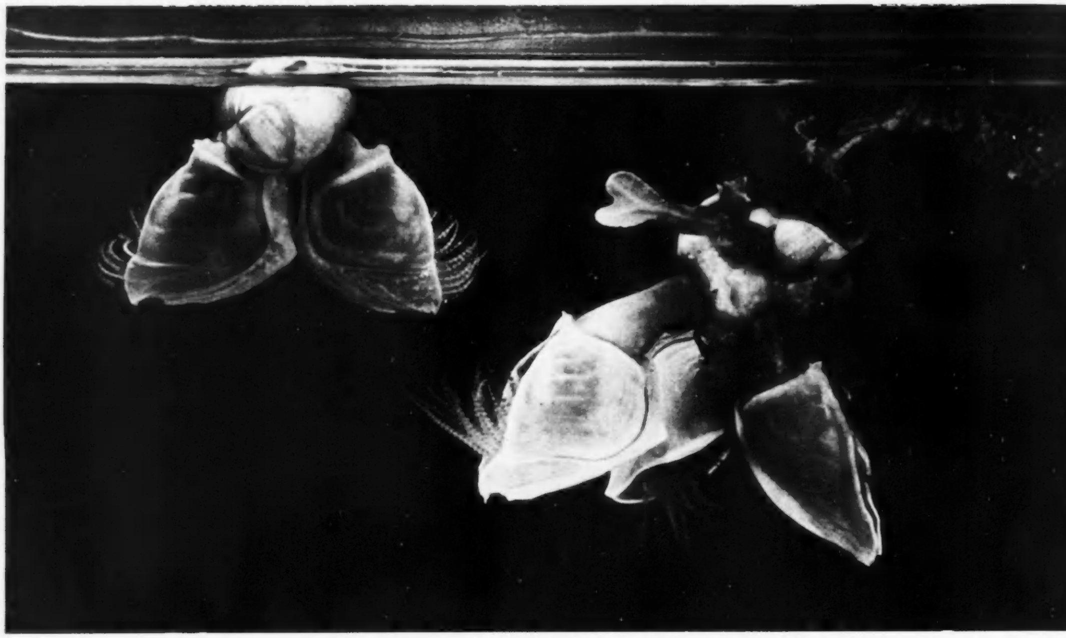


FIG. 6. The Buoy-making Barnacle (*Lepas fascicularis*). These animals secrete a bubbly float to keep them at the surface. They are to be found attached to drifting seaweed, and also to such floating objects as feathers. Their protective plates are thinner and less heavy than are those of the Ships' Barnacle.

FIG. 7. The Ships' Barnacle (*Lepas anatifera*); usually, many specimens are found together, attached to the same floating object. Attachment is by a long flexible stalk. The main body is protected on each side by a set of limy plates. Feathery limbs are swept through the water to capture small organisms drifting by.

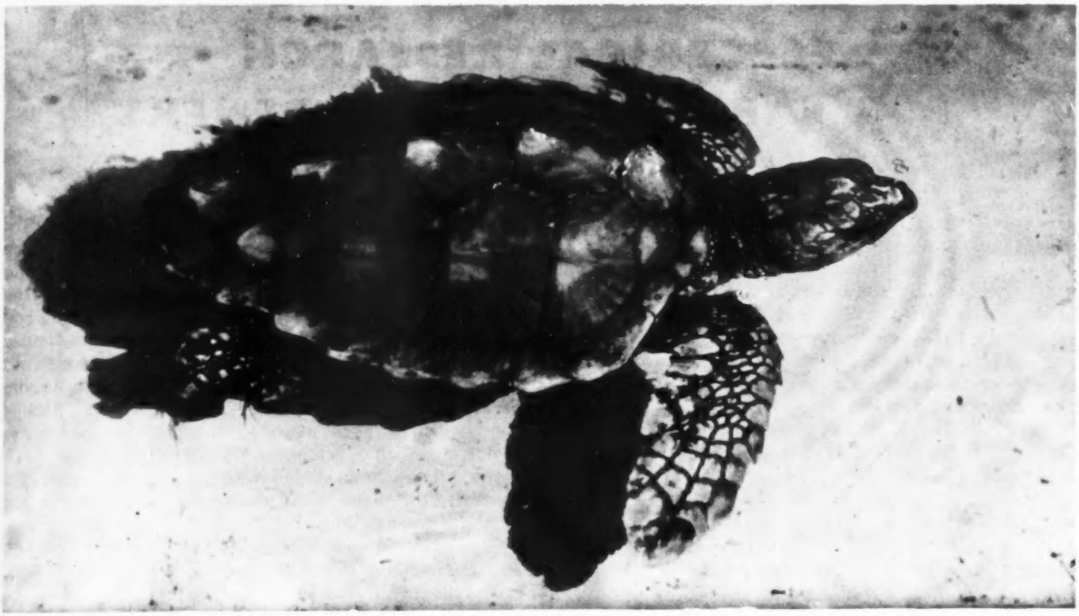


FIG. 8. A small Loggerhead Turtle (*Caretta caretta*) which was stranded at Bude, North Cornwall, in August 1945. Tufts of seaweed are seen attached to it; the alga was identified as a species peculiar to American seas.

Other float makers are the Violet-snails (*Ianthina*), which have lovely, fragile, heliotrope shells. Live specimens are sometimes washed onshore in the extreme west. The snails secrete a bubbly slime, to the underside of which some species attach their eggs. Violet-snails feed on jellyfishes and *Velella*.

In contrast to all the animals so far mentioned, turtles are strong active swimmers, and it is therefore a little surprising to find them included among our stranded visitors, though perhaps no more surprising than the running ashore of some whales, large fishes and other big marine animals. These turtles are generally small Loggerheads of two species; one of these is only known to breed on the American side of the Atlantic. The theory is that they are blown out of the Caribbean by violent storms and aided by currents and winds setting in our direction eventually make the crossing. One of the turtles stranded on a north Cornish beach in 1945 had growing on it tufts of an alga peculiar to America. Turtles spend much time with their backs out of water and exposed to the wind so they are liable to be affected by the direction in which the latter is blowing.

The Natural History Museum at South Kensington invites notification of all turtles taken on our coasts, and in this connexion has issued a leaflet to aid in the identification of the several species.

This article is not concerned with the many strange creatures from deep water which may come ashore from time to time, such as whales* which sometimes run ashore accidentally, or the rare specimens of giant squids, and sharks which are washed ashore dead or dying. But our list of oceanic surface organisms should perhaps be extended to include the strange Sun-fishes (*Orthagoriscus*) and the most brilliantly coloured fish on the British list, the Opah, or Moon-fish (*Lampris luna*). These huge fishes (they may weigh several hundredweights each) drift and wander at the ocean surface and are sometimes taken at sea close to our shores. The writer has seen two stranded Opah fishes separated by a time interval of about thirty years, and this gives some indication of the frequency with which the ardent shore collector may expect to find them. The last of these two specimens came ashore on the south coast of Devon in August 1945, just at the time when the vanguard of the great armada of Portuguese Men-of-war was reaching the north coast of the same county. This may have been mere coincidence, but also in the same month three turtles were stranded in the south-west, and all the facts taken together make it difficult to avoid the conclusion that the same winds and currents which brought the *Physalia* were also to some extent responsible for bringing the turtles and the surface-living and probably slow-swimming fish.

Strandings of the Portuguese Man-of-war, of turtles and of the larger fishes are of much interest to marine biologists and should be reported. The writer is always glad to receive records with localities, dates and, if possible, confirmatory specimens.† Strandings of *Velella* if alive and in number are also of interest, but strandings of the skeletons of the floats are of less significance, as are also strandings of stalked barnacles, the Ships' Barnacle being found relatively often on many coasts.

* Two relevant documents published by the Natural History Museum, South Kensington, are: *Report on Cetacea stranded on the British Coasts from 1933 to 1937*, by F. C. Fraser, 1946. *Guide for the Identification and Reporting of Stranded Whales, Dolphins, Porpoises and Turtles on the British Coasts*, by F. C. Fraser and H. W. Parker, 1949.

† These should be addressed to Dr. Wilson, The Laboratory, Citadel Hill, Plymouth.

ELECTRICAL RESEARCH FOR FARMERS AND GARDENERS

J. H. M. SYKES
A.I.E.E.

There are two methods by which the electrical engineer can assist the farmer, market gardener and nurseryman. The first is by the provision of a cheap and reliable electricity supply, and of electrical equipment to power agricultural machinery and provide the amenities of life without which he cannot attract the labour he requires. We are concerned here with the second method by which the aid of electricity can be given—the provision of means of control over natural forces. Fundamentally, any source of power can be used to drive, for example, a chaff-cutter, although electricity may be handier and possibly cheaper; on the other hand, it is only by the use of electrical methods that such operations as completely controlled soil warming can be carried out.

A recent opportunity of inspecting the centre of all research in this direction in Great Britain—the Shinfield Field Station of the British Electrical and Allied Industries Research Association (the E.R.A.)—provided an opportunity of making an assessment of the stage reached in the more refined and subtle applications of electricity in the rural sphere.

The destruction of pests has always been one of the major problems of agriculture. There is no need in these columns to elaborate upon the extent to which farm crops suffer from the depredations of insects, which also cause serious losses where grain and other agricultural commodities have to be stored in large quantities—F.A.O. has estimated that 5% of the world's cereal crop is destroyed by insects after harvest. Existing methods of pest control in stored grain have taken the form either of heating or of fumigation with an insecticidal vapour (e.g. carbon tetrachloride, methyl bromide). There are great difficulties in the direct application of heat of such a degree that the insects are destroyed without harm to the grain.

The E.R.A. have devised new equipment, which employs the principle of dielectric heating now widely used in industry. When an insulating substance is introduced between the plates of a capacitor—or 'condenser', as we used to call it—and an alternating voltage is applied, the electric stress so set up causes heating to take place. Dielectric heaters, using frequencies of the order of between 2 and 200 millions of cycles per second, are used to set synthetic resin glues instantly, to 'weld' plastic materials, to pre-heat the moulding powders used in making plastic articles, and for many other industrial purposes. The important point to realise is that the heat is completely controllable and—unlike heat applied from outside by such means as a flame—is generated right inside the body to be heated.

The E.R.A. have set up an experimental installation in which a dielectric heater is used to eliminate weevils in corn. The grain is passed between the plates of the capacitor, and the seeds rest under the electric stress for about 30 seconds. The heating effect is much greater on the insects than it is on the grain, since the body fluids of the weevils form a conducting medium in which relatively high currents can flow. In the demonstration given at Shinfield, the grain and the live weevils were placed in a two-compartment container, so that the action could be observed and the temperature of the grain measured by a thermo-couple. The weevils were seen to curl up rapidly when the power was switched on, while the grain did not attain a temperature of above 40° C at any time. The 'differential' heating effect, which forms the major advantage attributable to this device, was seen to be completely controllable.

It is estimated that some 1400 lb. of grain per hour could be treated by the use of a 25-kW dielectric heater, at a cost of about four shillings and sixpence a ton. Large-scale treatment would need to be carried out on a conveyor belt, and the method would be applicable to infested nuts, bulbs, dried fruit, cotton, for example.

Another form of pest control, the sterilisation of soil, can be carried out electrically in two ways. The first is the application of controlled heat, by the use of tubular immersion heaters buried in soil which is held in a metal-lined and thermally insulated box. The second method, which is both more elegant and more economical in first cost, is to use the soil itself as the heating element, by passing a controlled current through it between rod electrodes. The E.R.A. experiment showed a number of electrodes, disposed at various distances from each other, through which current was passed to heat up the soil. The effects of soil density, resistivity and humidity are being studied. It is estimated that about 1½ to 2 units of electricity are needed to sterilise each cubic foot of soil.

ELECTROCUTING WEEDS

The eradication of weeds appears at first sight to be a subject more for the attention of the chemist than for the electrical engineer; but there are many difficulties in completely killing the roots of stubborn weeds, and consequently the E.R.A. are experimenting with an electrical weed-killer of an entirely new design. The ordinary power supply is taken from a socket on a convenient pole and brought, by a flexible lead, to a 'generator', where it is converted to 1200-volt direct current. One pole is led to earth through a spike, and the other pole is taken, by a flexible insulated wire, to a 'probe' similar to a walking-stick, through which it passes to emerge at a shielded metal tip.

This tip is applied to the top of the weed, and there is an audible sizzle as the current passes from the probe, through the stem and all the roots of the plant, back to earth to complete the circuit. This electrocution process is completely effective and the plant can never grow again, since the heat generated by the passage of the current destroys the whole root structure. The technique is being considered in connexion with the eradication of bracken, a particularly

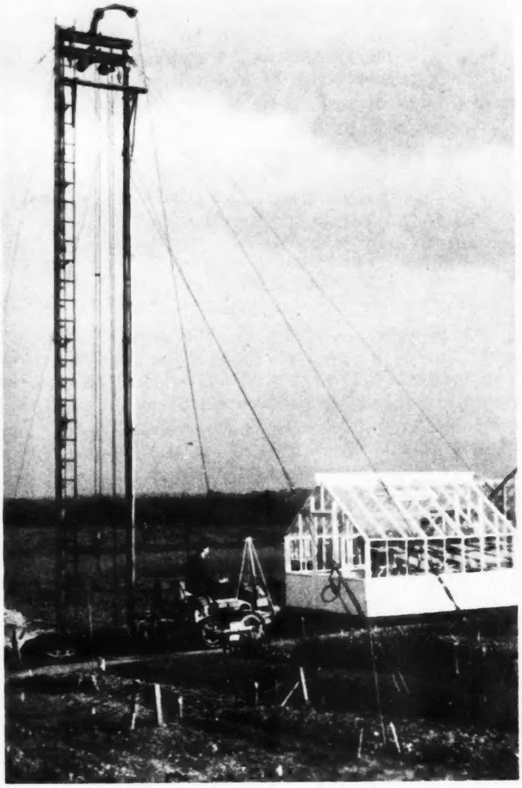


FIG. 1 (*above left*). All the land at the Shinfield station is cultivated by this electric tractor, which is an ordinary machine powered by a 6-h.p. motor. The use of electric power costs about a third of the usual running cost with paraffin, and among other advantages is the fact that full power is available at the slowest speeds. The main problem is to perfect a suitable electric cable.

FIG. 2 (*above right*). The smaller of the two experimental devices designed for electrocuting weeds: its probe carries 700–800 volts, and is effective for beet singling.

FIG. 3 (*right*). This research unit pioneered the use of electrical soil warming in propagating frames and under cloches. Now it is experimenting with electrical warming of open ground, using a cable about 9 in. below the surface to give 60–90 watt-hours per square foot per day. Commercial flower growers may find this economic; gladioli are ready for market two weeks earlier, and three weeks are gained with daffodils.

difficult weed to deal with and one that neutralises many acres of useful land, and a large-scale experiment is under way. While the E.R.A. do not claim that the device has a commercial application in its present form, it nevertheless points the way to a new and potentially highly efficient use of electricity on farms and in market gardens.

The smaller of the two electrical weed-killers with which E.R.A. is experimenting provides a useful tool for beet singling, an operation not easily done without upsetting to some extent the growth of the sugar-beet seedlings that remain after singling.

THE HEAT PUMP IN THE DAIRY

For many years it has been found desirable to cool milk from the temperature (about 98° F) at which it is drawn, to ensure that it will keep fresh, and many dairies have refrigerating plants. The heat removed from the milk, by the expenditure of electrical energy in the refrigerating plant, has in the past been entirely wasted. The heat pump, which consists in essence of a reversed refrigerator, has now been brought into use, in an experimental fashion, by the E.R.A. to use the heat removed from milk to warm the farm buildings and to provide hot water for such purposes as washing the dairy implements.

The milk is poured over a conventional type of cooler, but the internal pipes are connected to the heat pump, which transforms the heat into a higher temperature form and delivers it at 130° F into a storage tank. In doing so, the incoming water, at ordinary mains temperature, is made to cool the milk to any desired temperature, usually about 45° F. In the small-scale installation at Shinfield, the heat in about 30–40 gallons of milk, when passed through the cooler, will warm about 25 gallons of mains-temperature water to the temperature indicated above, with an expenditure of electrical energy which is only 5% greater than that needed for ordinary refrigeration where the whole of the heat withdrawn from the milk is wasted. The emphasis in this particular research project is to perfect heat-pump equipment suitable for use with an average-sized herd of about 20 cows.

Incidentally, the workshops and laboratories at the E.R.A.'s field station are all heated by a heat pump.

A considerable area of land is devoted to soil-warming experiments of various kinds. The E.R.A. have, since the inception of their rural Electrification Section in 1938, been pioneers in this field. Early experiments employed specially insulated soil-heating cable, operated at ordinary mains voltages; but the later trials have mostly been carried out by the aid of bare wires, buried in the ground and fed at about 30 volts from step-down transformers installed near the beds. The methods now in use for accumulating data on the effect of various types of soil warming usually consist of providing daily 'doses' of energy, by automatically switching on the heating circuit for varying periods in each twenty-four hours, each dose consisting of about 0·04 to 0·055 of a unit of electrical energy per day per square foot. At Shinfield these methods are applied experimentally to frames, glasshouses and to open-air plots with and without cloches. Their experiments with soil heating of open ground are unique; and the responses of various crops to soil warming in open-air beds with doses of energy varying between 0·09 and 0·06 of a unit per day per square foot, are being compared with crops grown in similar unheated plots near by.

In one of the glasshouses, in addition to soil warming, an extensive series of experiments on the use of various types of artificial light—neon, mercury, sodium, fluorescent and ordinary tungsten filament lamps—has been in progress for a considerable period. Some eight to ten hours of supplementary light daily, for three weeks after the seedlings are potted, is a typical dosage, and the results indicate the predictable nature of the increase in weight and height which can be expected in suitable cases.

EGG-LAYING POULTRY AND FLASH ILLUMINATION

The use of electric lighting in yet another direction was seen in one of the most interesting of the research projects in progress at Shinfield. It concerned the possibility of stimulating winter egg production from laying poultry by supplementing artificially the hours of daylight. This research work is being carried out in conjunction with Reading University's Poultry Research Station, which adjoins the E.R.A. field station. Three sets of identical birds are used, and the first set (A) have no artificial light, the second set (B) have artificial lighting, from tungsten lamps, to bring their 'working day' up to a total of 14 hours; while the third set (C) have a type of 'flash' illumination which is yielding some results of extraordinary interest. The 'C' birds receive only two 20-second flashes of light, at 4 a.m. and 4.45 a.m. each day, provided automatically by means of 1500-watt lamps operated by a time switch. The results show that almost as great an increase in egg production is obtainable by this means as by the lengthy periods of ordinary lighting. Curves which showed the result of nearly a year's experimental work revealed that while both methods of artificial lighting tended to become less effective the longer they were employed, nevertheless typical egg-production figures for a recent week, with birds who had been living under the A, B and C conditions for some months, were as follows: A, 58; B, 74; and C, 65, these figures being expressed as percentages of the total possible egg production per bird. Thus the birds subject to flash illumination, which involves a comparatively small expenditure in electrical energy, showed a 7% increase when compared to birds with no lighting at all, and their egg production was only 9% below that of birds working under fully extended daylight conditions. The egg weight and the health of the birds had not suffered in any way.

It is still unfortunately true that only a little over one-third of the farm premises in Great Britain are connected to the public supply mains; and as the chairman of one Area Electricity Board said recently, there are bound to be cases of isolated farms where the cost of laying down the overhead wires is such that any possible revenue from the consumer cannot pay for the interest on the capital charges so incurred: and moreover it is not possible to ask the farmer to contribute to the cost of the installation, since he would find it an uneconomic proportion of his capital expenditure. It may be that some type of subsidy will be evolved to deal with this problem; but in the meanwhile the E.R.A. showed that they were not unforgetful of the

FIG. 4. Artificial light is being tried for a variety of purposes in horticulture. This picture shows the stimulating effect of light from mercury lamps on cucumber seedlings; the treated plant on the left is exactly the same age (6 weeks) as the other, which was grown without artificial illumination. The temperature in this experiment was low. At Shinfield plants are being cultivated under several different types of lamps.
(*G.E.C. photograph.*)

needs of the farmer who had no electricity supply from the mains. The extensive work carried on by their Wind Power Research Section showed that a great deal has been done to make wind power more practicable. The first essential, of course, is to be able to measure the wind energy available in any particular locality; and for this purpose the E.R.A. have evolved special anemometers and other measuring instruments. By the aid of these devices they have completed a wind-power survey of Great Britain, and have been able to evolve directives which indicate the best site for a particular windmill in relation to the slope of the ground, the direction of the prevailing wind, and other local factors. Methods of storing the energy provided, and the evolution of special applications which will improve the economy of wind power, are also the subject of intensive research and development.

All the research work briefly mentioned above, together with a number of other experiments on improved crop-drying methods, the design of electric tractors, and so on, is directed towards providing fundamental data which may later be used by manufacturers to produce equipment for commercial use; but one exhibit deserves final mention as indicating the imaginative approach which must always be at the back of the minds of those concerned. It took the form of a full-scale model of the glasshouse of the future. The sun's rays were automatically controlled by the use of coloured water streams running down the glass panes, the flow being regulated by means of a photo-electric cell so that only a predetermined amount of sunlight was allowed to reach the plants. The soil—previously electrically sterilised—was fed by pipes carrying controlled quantities of phosphates, potassium and nitrogen. Water, warmed to a controlled temperature, was fed in at predetermined times to the electrically heated soil. Air conditioning determined the humidity, carbon dioxide content, and temperature of the air (and eliminated airborne pests); and all these quantities could be electrically registered on recording instruments. In this way, the horticulturist of the future might set in motion a growing programme that would have the result of producing plants almost as rigidly similar in weight, appearance, flavour and date of ripening as can be achieved in the case of stamped-out components from a mass-production factory.

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THE GEOLOGY OF ORNAMENTAL STONES

FREDERICK A. HENSON

B.Sc., Ph.D., F.G.S.

The attractiveness of the exteriors of many new buildings, especially the steel and concrete structures which have risen from the ruins in our war-damaged cities, is often due to the thin veneers of specially selected ornamental or decorative building stones which cover the gaunt basic structures. In most cases such highly polished veneers are only one to two inches thick. Not all of these new buildings, however, are clad in panels of polished or dressed stones, for in recent years many advances in the treatment and finish of concrete surfaces have been made, and today a great variety of attractive synthetic stone surfaces can be produced. In this article some of the commoner ornamental stones, used in interior as well as external decoration, will be considered from the geologist's viewpoint, and the conditions under which such rocks have been formed in nature outlined.

The choice of a suitable exterior ornamental stone is primarily controlled by cost, resistance to weathering and its durability under the corrosive conditions imposed by the atmosphere in which it will be exposed. As a general rule, the more attractive rocks are expensive and their use is therefore restricted to positions where they will be se n to maximum advantage. For this reason, in actual practice, it is only the bottom ten to twenty feet of our larger city buildings which are decorated to any extent in this way. Thus, at eye level, or just above it, the man in the street sees a magnificent display of polished and trimmed stones, representing the wide range of ornamental stones from this country and Europe.

The first property to be considered is resistance to weathering, which depends on a number of factors. It varies according to the mineral composition of the stone and the size of the different mineral particles which make up the rock; the rate of weathering is affected by the existence of pore spaces, and in the case of sedimentary rocks it will depend largely upon the nature of the cementing material.

Sandstones, composed of sand grains (and perhaps including particles of a few other minerals such as felspar and mica in subordinate amounts) and bonded together by lime, iron, silica or some other cement, have very varied uses and applications as ornamental stones. Where the sand grains are small, uniform in size and cemented together by silica, the rock may not only be attractive but will withstand the weather. If, on the other hand, the grains are variable in size and loosely cemented by calcium carbonate, the rock would weather badly in industrial areas, the reason being that acids in the atmosphere dissolve the calcareous cement and so cause disintegration of the rock. Another characteristic of some sandstones is that they possess fine partings which are layered with small particles of mica: this tends to break up into flakes, and is thus a source of weakness in such rocks. In a climate such as ours the pore spaces in the outer exposed parts of loosely cemented rocks are frequently filled with water. During frosty weather this water freezes within the outer shell of the stone, and the resultant expansion causes mechanical break-up of the rock. An additional fact which makes sandstones unpopular in industrial areas is that although a particular sandstone may be cemented together by silica and be sufficiently compact to resist mechanical and chemical weathering, it may have the kind of surface that offers lodgement for soot and so becomes rapidly disfigured. Such rocks, unlike limestones, have no self-cleansing properties.

Limestones, on the other hand, are gradually eaten away by the action of carbon dioxide dissolved in rain-water, and sulphur dioxide present in the polluted atmosphere of our cities has a similar effect. Such rocks, because they undergo continuous chemical weathering, exhibit comparatively fresh and attractive surfaces. This self-cleansing property is one of the many attributes of Portland stone, which, because of its uniform character and the small size of the small oolitic grains of which it is composed, is capable of taking a great variety of finishes. Some limestones harden on the outside after they are quarried and exposed to the atmosphere; in such cases removal of the 'case-hardened' outer layer by excessive cleaning and the use of abrasives may assist the destruction of the mass of stone in a building block or ornamental veneer.

SANDSTONES

Many sandstones, owing to their fine and uniform grain, lend themselves to intricate working (although they are less popular than limestones for the reasons indicated above) and are quite commonly used as ornamental stones in many of our towns and cities. Those which have been widely used in this country come from the Carboniferous

FIG. 1. Disintegrating sandstone blocks in a wall on the outskirts of an industrial area. Each block is roughly 12 in. long. One or two of them show the marks of the stonemason's chisel still preserved, though the majority have weathered considerably to reveal the bedding planes in the rocks.

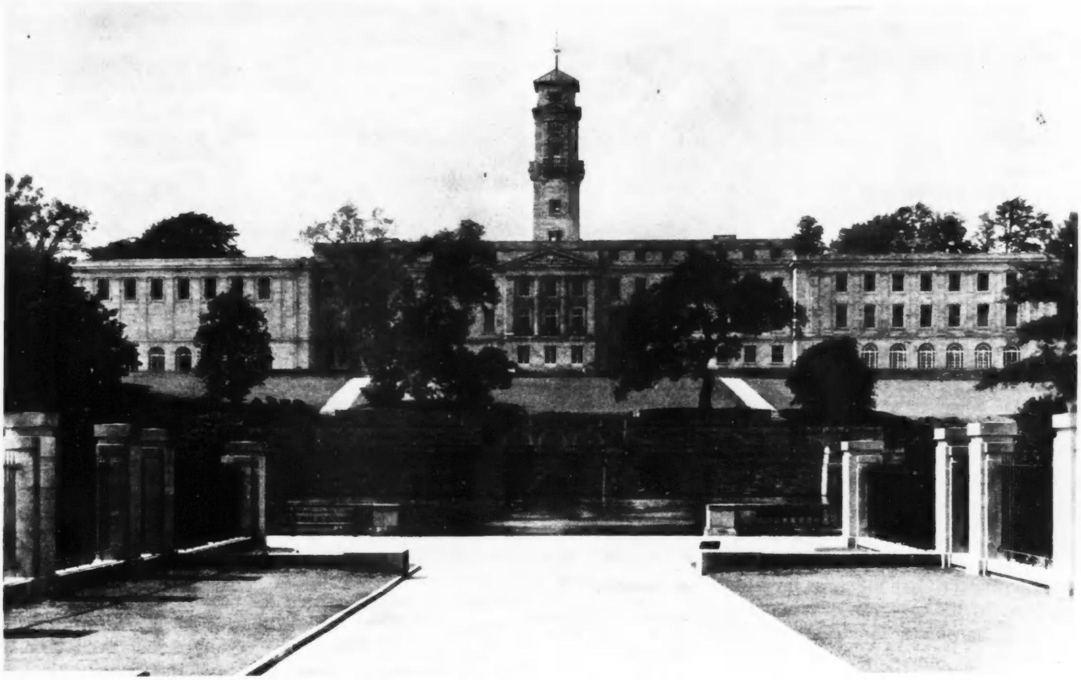

FIG. 2. The main building of Nottingham University is built of Portland stone. The lower and darker stonework above the lake is of sandstone of Carboniferous age.

rocks of Yorkshire and Derbyshire—stone from Darley Dale, near Matlock, for example, provided the sandstone which forms part of the Thames Embankment.

In the Forest of Dean and South Wales the Pennant sandstones have been worked for centuries for both building and decorative work. These grey and blue sandstones are softer and more easily worked than some of the very hard, fine-grained Yorkshire sandstones, which are used for terraces and similar work.

LIMESTONES

The chief sources of ornamental limestones in this country are rocks of Jurassic age. Their main outcrop is a broad band stretching from the Dorset coast, through Somerset, Gloucester and Northamptonshire, and on to the Yorkshire coast between Tees Mouth and Filey Bay. These rocks, which include clays and sands as well as limestones, were formed at a time when numerous small-scale oscillations of the level of the sea took place. The limestones were formed in fairly shallow warm waters, and throughout the period life was dominated, both on land and in the sea, by giant extinct reptiles. They are mainly oolitic in texture, that is, they are composed of small calcareous concretions, more or less spherical and rarely exceeding 2 mm. in diameter; such localities as Ancaster, Bath, Clipsham and Portland are renowned for fine building and ornamental limestones of Jurassic age. All these limestones are marine in origin, and contain masses of shells and shell fragments cemented together by crystalline calcite as well as the uniform oolitic grains. In colour they vary from pale cream to buff, depending upon the amount of iron oxide present, and they are to be seen in most of our towns and cities.

Most popular of all the Jurassic limestones is the *Portland stone*. Sir Christopher Wren used this fine stone extensively in rebuilding London's churches after the Great Fire of 1666. He employed it both as a facing material and as the principal structural material. St. Paul's Cathedral is built of Portland stone and has withstood over two and a half centuries of English weather and London grime remarkably well, as on the more exposed parts of the Cathedral (particularly the south and west fronts). Even where the stone has been eaten away, the off-white weather-beaten appearance is still attractive, whereas there is some disfigurement by sooty deposits where the stone is protected from the weather.

Next in importance is the *Bath stone*, which is both older and darker than the Portland stones. Its use is mainly confined to churches and public buildings in southern England, although this mellow stone has been used as facing material to cover the rough brickwork of many a town and country house. No account of the Jurassic limestones would be complete without mentioning the *Clipsham and Ketton stones*; the former were used to rebuild the House of Commons after the war.

MARBLES

In the building trade 'marble' denotes any soft rock, usually a limestone, which will take a polish and can be used as a decorative stone. To the geologist a marble is a metamorphic rock formed by the alteration of a lime-rich sedimentary rock, such as limestone, by the combined effects of temperature and pressure during the time such a limestone was a geosynclinal sediment.* At such a time, at depths of several thousand feet and near to large masses of molten rock material (magma), an original pure, shelly limestone will fuse and eventually recrystallise to form a coarse-grained marble composed of interlocking calcite ($CaCO_3$) grains in which no organic structures remain. In the case of an impure limestone, other new minerals besides calcite may be formed during recrystallisation.

The British limestones which have been used as marbles will be considered first. In the neighbourhood of Newton Abbot, Torquay and Plymouth, limestones of Devonian age, which are older than rocks of the Carboniferous period, were at one time extensively quarried for their marbles. These limestones, which vary in colour from pale yellows to reds to greys and black, contain abundant exquisite coral remains. They were often used for internal wall panels and columns during Victorian times.

At Hopton Wood, near Middleton in Derbyshire, the hard, compact Carboniferous limestone was considerably changed by the injection of molten igneous rock between the bedding planes. One of the main changes which this molten rock caused in the limestone was the partial recrystallisation of the calcite matrix; the final result was a rock that was both more compact and harder. The Hopton Wood limestone, which is available in two shades of pale brown, is unsuitable for external use, but since it takes an excellent polish, it is well suited for panelling and other work on interior walls. A good demonstration of its attractiveness can be seen on some of the interior walls of the main building of the University of Nottingham. Close examination of this limestone reveals an abundance of shell fragments, crinoid stems, corals and other fossil remains of organisms which lived in the warm waters of the sea at that time. These organic remains accumulated amongst the calcareous oozes which became the Carboniferous limestone, which was formed before the Coal Measures were laid down in the deltaic swamps which eventually followed.

From the Jurassic, two formations have in the past enjoyed considerable popularity as 'marbles'. In the older *Forest Marble* formation, which overlies the Great Oolite, the thin oolite and shelly limestones have been occasionally used for ornamental purposes from Roman times. Above the main Portland limestone, in the Purbeck Series, the *Paludina* limestone or Purbeck Marble is a very attractive rock. Again this is not a true marble, and although it will take a good polish it is unsuitable for external work. This stone was extremely popular over a hundred years ago, and for some centuries earlier it was in common use. It is to be found in many churches, being used extensively in Salisbury Cathedral.

From Iona, Argyllshire, a beautiful white and green marble has been quarried for ornamental purposes. This stone, which is similar to the Irish marbles (especially the Connemara marble), is the result of recrystallisation of impure magnesium limestones which contained abundant quartz grains. During the recrystallisation the magnesium silicate mineral known as *forsterite* was formed; this was subsequently hydrated to green serpentine or ophicalcite.

There are no pure white statuary marbles in this country. This type of marble has to be imported, mainly from Italy.

* Readers are referred to the full page of diagrams (p. 274) in our September 1952 issue which explains the sequence of events constituting the history of a geosyncline.

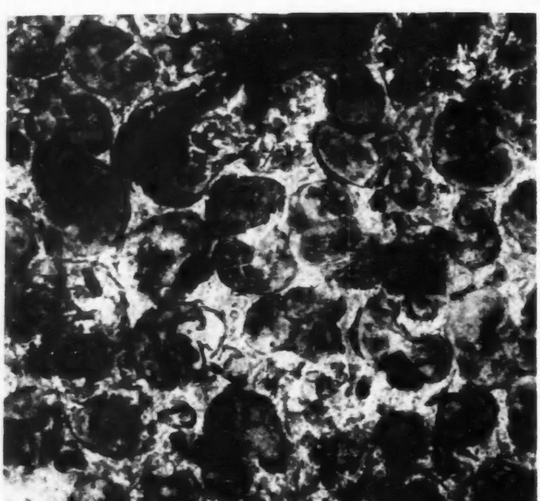

FIG. 3. Paludina limestone from Purbeck: natural size. The name 'Purbeck Marble' is scientifically inaccurate.

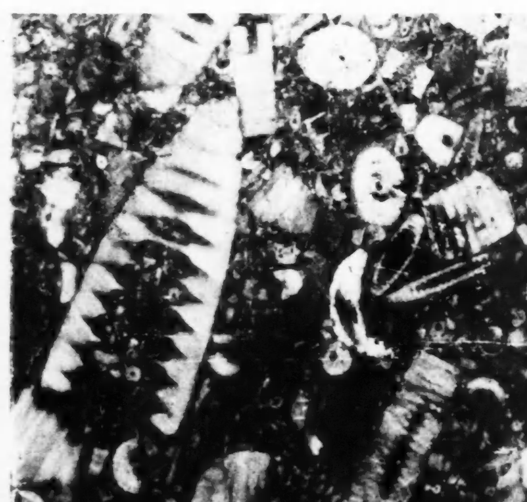

FIG. 4. Fragments of fossilised crinoids (sea-lilies) in Carboniferous limestone from Derbyshire. Natural size.

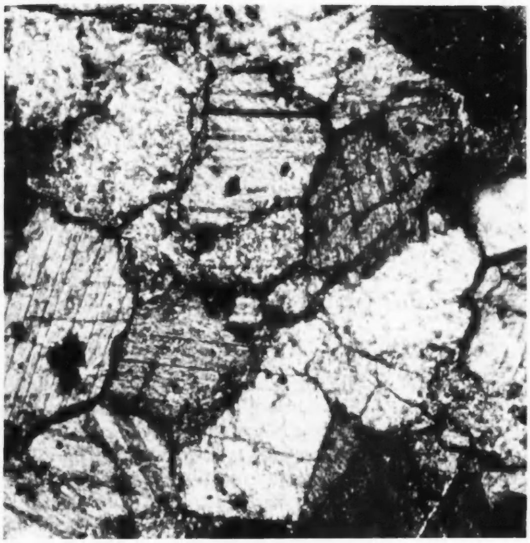

FIG. 5. Carrara marble under the microscope, showing interlocking calcite crystals. $\times 32$.

FIG. 6. Norwegian syenite (larvikite), commonly used to decorate shop fronts. The light-coloured iridescent crystals are of the felspar called labradorite.

Variegated marbles are obtained from nearly all other European countries.

In Italy the ancient quarries at Carrara have been worked for almost two thousand years to provide marbles for statuary and other uses. These quarries also provide the white-veined, variegated varieties used in architectural work. Many of the majestic buildings of ancient Rome were built of Carrara marbles; many still survive to this day in excellent preservation, although they are often discoloured. In this country, marble does not withstand exposure well, and, furthermore, on account of its cost, its use is mainly confined to internal work; there are, however, some notable exceptions.

Pure white marbles are the result of recrystallisation of originally pure limestones, i.e. limestones comparable with the Jurassic oolites, which contain up to 98% $CaCO_3$. In variegated and mottled marbles the delightful diffuse patterns and colours are the result of the recrystallisation of limestones which contained varying amounts of other materials such as clay minerals or minute specks of iron.

Marbles such as the black-veined varieties represent very impure calcareous rocks which have been broken by earth pressures and subsequently veined by calcite.

In such rocks both mineralogical and structural changes have taken place; the movement or flowage of the rock took place under considerable pressures and at temperatures well above normal. In the extreme case, the different bands in the original limestones were broken up, mixed and recrystallised to form the delightful and attractive multi-coloured marbles, which were at one time so popular for interior decoration in large buildings. Examples of the uses of marble are too numerous to mention; some are magnificent, others deplorable: whilst quite a few samples that look like marble are not the products of nature at all, but are the result of the skilful and ingenious use of coloured Portland cements. Londoners, however, have their own Marble Arch, constructed of Carrara marble from the Pavaccione quarries in the Apuan Alps.

GRANITES

Unlike the ornamental stones already described (all of which, with the exception of the true marbles, are sedimentary in origin), the granites were formed from molten rock or magma which at one time was intruded deep down in the earth's crust. Such rocks cooled comparatively slowly, and under such conditions the various constituents were able to crystallise out to form these coarsely crystalline rocks. The word granite is derived from the Latin *granum* (a grain), which aptly describes the texture of these rocks which consist of the minerals quartz, felspar, mica and various other minerals. The felspars are both alkali (orthoclase) and lime-soda (plagioclase) in chemical composition, whilst both the light (muscovite) and the dark (biotite) varieties of mica may occur singularly or together.

The granites provide a great variety of both ornamental and building stones. In colour they show a considerable range, from the pale-grey Dartmoor granite to the darker red and grey-blue granites from Shap and Aberdeen. In texture these rocks show many variations; commonly the various constituents are present as crystals all of approximately the same size; there are, however, quite a few types of granite in which larger felspar crystals, two to three inches in length, stand out from the fine matrix of quartz, felspar and mica.

The Dartmoor granites are generally pale-grey in colour and fairly uniform and fine-grained. There are some varieties which are really coarsely porphyritic, with felspar

crystals two to three inches in length and a pale brown in colour. The mica in these granites is predominantly of the black variety called biotite; in some varieties the white mica muscovite and the mineral tourmaline also occur. The neighbouring Cornish granites are conspicuously porphyritic, with large white felspars over an inch in length. Variations of colour do occur in these granites, from a greenish to a blue-coloured rock in the various localities in which the stone is quarried.

Many large areas of the Cornish granites have been kaolinised, an alteration process in which the felspars decompose to china clay and sand grains. Such rocks are of no use for building or ornamental stones, since they are so soft that they crumble on exposure. This fact is, of course, used in the china-clay workings, where jets of water are played on to the granite to wash out the clay. In other parts of Cornwall the granites are both uniform and tough rocks capable of withstanding exposure and taking high polish. A delightful variation of these granites is shown in the granites from Luxullian. Here the granite, during the final stages of its cooling from the magma, was affected by volatile gases which entered fissures and cracks in the almost consolidated rock and partially altered it. One of the chief effects is shown by the original felspars and micas which have been 'tourminalised'. Luxullianite, as this variety of granite is called, is an attractive rock in which the original porphyritic pink felspars, up to an inch or so in length, stand out in contrast to the dark-blue tourmaline and the unaltered quartz. This rock was used for the tomb of the first Duke of Wellington in St. Paul's Cathedral.

From Wasdale Crag, Westmorland, the Shap granite has been quarried for a long time. This rock is easily recognised by its characteristic large crystals of pink felspar, which are scattered throughout a matrix of smaller felspar crystals, black mica and quartz. This granite has been very frequently employed as an ornamental stone, especially in late Victorian times. The columns of polished Shap granite at St. Pancras Station are of this stone; they also show the black blemishes or 'heathen'.*

Scotland and Ireland both produce excellent granites which have been extensively used for external decoration, either as polished or trimmed stones. In London, granites from Norway, Sweden and many other countries have been used. Perhaps the best-known example of an Egyptian granite is Cleopatra's Needle; this granite is one of the hornblende-bearing varieties; in composition and texture it is similar to some of the Scottish granites.

SYENITES

These igneous rocks take their name from the Syene district in Egypt where they were extensively quarried by the Egyptians thousands of years ago. Syenites have a granitic texture but contain no quartz; the constituent minerals are the alkali felspars, plagioclase and a ferromagnesian mineral, principally hornblende. These rocks are much darker than the granites, but they are of limited distribution. In Great Britain, syenites occur in the Mountsorrel area, Leicestershire.

Ornamental syenites, known as larvikites, from the Oslo district of Norway, are commonly used in this country. These delightful rocks, sometimes facetiously referred to as 'public-housite' or 'pub-ite', are dark blue in colour and characterised by large felspars which show a typical blue butterfly-wing iridescence when looked at in certain directions. This iridescence is due to the development, along cleavage planes within the felspar, of minute inclusions which cause internal reflection of the light. The two types of larvikite in general use, the Royal Blue and the Emerald Pearl (the light variety), are both coarse-grained and are most frequently used for shop fronts.

SERPENTINES

Because of the richness and variety of its colouring, serpentine is one of the most attractive of all the ornamental stones. It is especially suitable for internal work, is comparatively soft and takes a good polish. When exposed to atmospheric conditions it tarnishes and decays. In mineralogy the term 'serpentine' is used to denote a magnesium silicate, commonly green or greenish yellow in colour, occurring in metamorphic rocks as a secondary product after the mineral olivine or other ferromagnesium minerals. When used, as in this case, to describe a rock type, the term is expanded to include a metamorphic rock chiefly or wholly composed of the mineral serpentine.

In the Lizard area, serpentine has been worked for a long time. The rock there is very variable in colour, but it is mainly of a deep olive-green, variegated by veins, bands and patches of rich deep red or lighter-coloured material. Visitors to Kynance Cove will be familiar with its wide range of colours, and some of the local uses to which this rock is put. Four quite distinct types of serpentine occur in the Lizard area, and the total area of outcrop is several square miles.

MISCELLANEOUS

Under this heading are included two ornamental stones which are worthy of mention; these rocks are used both as building and ornamental stones. Firstly, the straw-coloured tufaceous limestone, known as travertine, which has been used in Italy for centuries. This stone, known to the ancients as *lapis Tiburtinus*, is formed by the chemical precipitation of calcium carbonate. Such limestones are both cellular and porous; they often show a wavy lamination. In the Naples area a similar calcareous tuff contains volcanic materials which give the rock a darker tint than that used in Rome. Travertine is easily cut when it is freshly quarried; it hardens on exposure, but is unsuited for use in this country.

In some cities ornamental stones which resemble granite, although they show a roughly common orientation of their constituent crystals, are to be seen; such rocks are known as gneiss. These banded or streaky rocks, in which the granular minerals predominate, are the final results of both sedimentary and igneous rocks alike being so altered by heat and pressure during their long history that no trace of the original structures remains.

* The term 'heathen' is an old quarryman's term used to describe these patches of quite foreign rock which are considered to be the remnants of both older sedimentary and igneous rocks which were caught up in the granite magma and were very much altered both mechanically and mineralogically during the time the granite was formed.

CULTURE COLLECTIONS OF FUNGI

H. A. DADE
A.R.C.S.

Culture collections of micro-organisms are today quite indispensable. This article, explaining the particular importance to the progress of science, medicine and industry of fungus collections and describing the activities involved in maintaining such collections, is written by the assistant director of the Commonwealth Mycological Institute at Kew who is responsible for the principal collection in Britain. A pictorial impression of the work which such centres do is conveyed by our illustrations taken at the Centraalbureau voor Schimmelcultures at Baarn.

The oldest of the great collections of living fungi is the Centraalbureau voor Schimmelcultures at Baarn in Holland and the name of Dr. Johanna Westerdijk, who has been its director for 46 of the 47 years of its existence, is a household word in every mycological laboratory in the world. Nearly 9000 strains, representing between 4000 and 5000 species of fungi, are kept in culture at Baarn, and their maintenance in good condition is an imposing task. In addition to these cultures, a large collection of yeasts is kept in a separate division of the C.B.S. at Delft, which is in charge of Dr. A. J. Kluyver.

Dr. Westerdijk has likened her work to gardening on a small scale—an apt simile, for these minute plants require a variety of treatments, and while their nutrition calls for the use of many organic culture media, they are subject to hazards similar to those which occur in flower beds: they are sometimes overgrown by weeds (intruding moulds or bacteria), and they can be parasitised by other fungi, or they may be eaten by mites which gain entry to the culture vessels. Protecting or delivering the rightful occupants of the tubes from these depredations is often a difficult task for busy curators.

When grown on unsuitable media most of the micro-fungi will not form the structures which produce spores, and without these characteristic structures they cannot be identified. Moreover, even on the best media which we know, the ability to sporulate is commonly lost after a time, and then the cultures are useless from the taxonomic point of view. Numerous factors, many of them unknown or only imperfectly understood, affect the suitability of nutrient media. Since fungi are plants without chlorophyll, they cannot make their own carbohydrates and thus carbohydrate in some form is an essential constituent of culture media; but too much carbohydrate, especially if it is supplied in the form of monosaccharides, is very likely to inhibit spore formation. Mineral salts must also be supplied, including several essential trace elements. Synthetic media, comparable to the hydroponic solutions used for green plants, are not generally satisfactory, and most mycologists prefer decoctions of vegetable materials; such liquors are converted into solid culture media by the addition of agar. Sterilised plant tissue, such as twigs and roots, are often used. The osmotic pressure of the medium is occasionally of critical importance; this applies to a few fungi which have become adapted to growth on concentrated solutions of brine or sugar, for instance. The degree of intensity of light and ventilation also have remarkable effects on the behaviour of moulds.

The methods of pure culture to which we are restricted by our present knowledge and facilities are by no means ideal. Growing fungi on nutrient agar or heat-sterilised organic media in glass vessels imposes conditions which are far from natural. Unless it is supplied from lamps, ultra-violet radiation is virtually prevented from reaching the cultures; nutrient jelly does not resemble the organic materials on which fungi grow in nature. Moreover, the condition of pure culture is itself artificial; in nature fungi do not grow alone, but are usually associated with other species, as well as with bacteria and other organisms. In culture, some forms will not sporulate—some indeed will not even make good vegetative growth—unless they are provided with a companion fungus or are supplied with extracts of the metabolic products of another suitable species. This phenomenon, which is well known in certain extreme cases, may be more common than we suspect, and increased knowledge of fungus ecology may enable us to achieve greater success in maintaining living fungi in normal vigour and typical morphology.

Common saprophytic moulds like *Aspergillus* and *Penicillium* give the least trouble to the fungus gardener, while the plant pathogens, adapted as they are to growth in living tissues, are the most difficult. Some pathogens in fact cannot be grown in artificial culture at all, though new techniques of tissue culture have made it possible in a few difficult cases. Good results have been obtained by cold-sterilising organic materials with a chemical disinfectant (propylene oxide), a method which causes none of the drastic changes induced by heat-sterilisation.

Fungi in culture must be replanted at intervals of a few weeks or months, and in a large collection this involves a great deal of work. In recent years two methods have been introduced with the object of partly reducing the labour of replanting and the incidence of mutation. The first of these is the lyophil process which consists of rapidly extracting the water from a frozen suspension of spores under vacuum. While this method is apparently successful in the case of bacteria and of fungi which make dry, powdery spores, it is fatal to others, and is not therefore generally useful to the mycologist. When it works, the dried spores, which are kept in sealed glass tubes, remain viable for years. In the other new technique, cultures on agar are covered with a deep layer of mineral oil (e.g. medicinal paraffin) to exclude air. Though more generally practicable, the oil method involves expenditure of time and labour in other ways, and it has not found universal favour in public collections, where the conventional method of replanting from agar to agar continues to be used.

The cultural techniques which apply to fungi resemble those used in bacteriology, and the same glass vessels—test tubes, flasks, Petri dishes—are used. There is a tendency to replace the conventional test tube, with its cotton-wool plug, by the McCartney bottle, such as is employed very

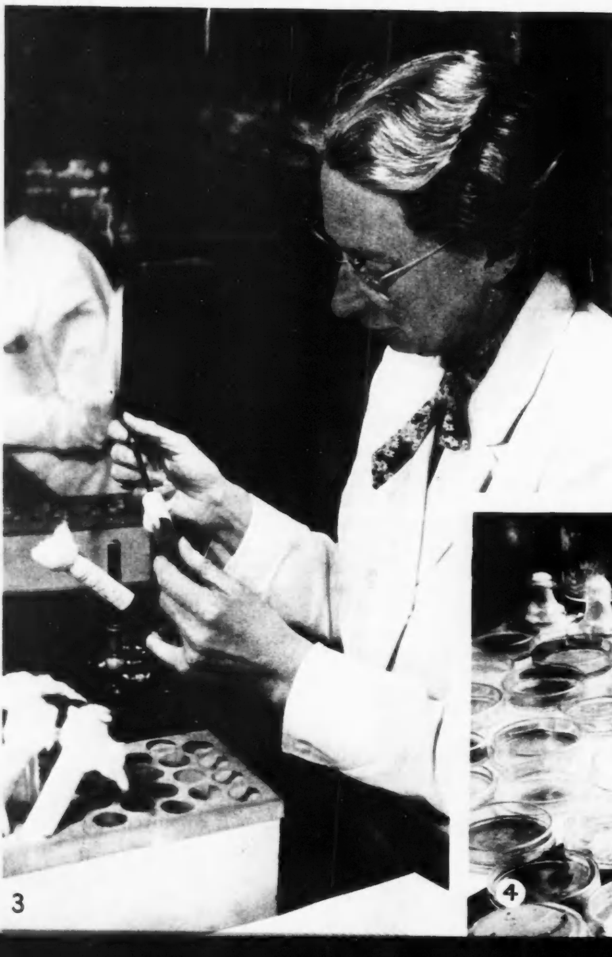

FIG. 1. Some of the Centraalbureau's 8600 isolations are stored in these test tubes. Dr. Van Beverwijk, one of the mycologists, is bringing down a file of cultures which are due for their four-monthly transplantation.

FIG. 2. Dr. Johanna Westerdijk, 70-year-old Professor of Amsterdam and Utrecht Universities, works at Baarn, where she has for 46 years directed the Centraalbureau, which is the biggest of its kind in the world.

FIG. 3. Miss Bunschoten, mycologist, transplants some of the 7500 fungi which must be replanted every four months. Certain delicate species must be transplanted more frequently.

FIG. 4. Moulds are grown at first in Petri dishes.

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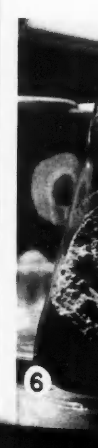

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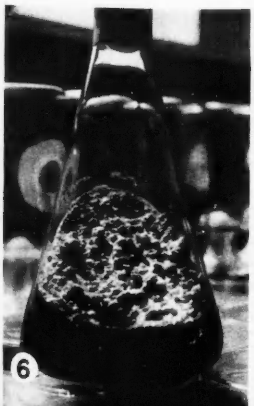
FIG. 5. Senior mycologist Dr. Vries studies a mould which is being grown under special light conditions. In this room experiments are being made with moulds growing under lights of different colours, to determine the most favourable conditions for their growth and propagation.

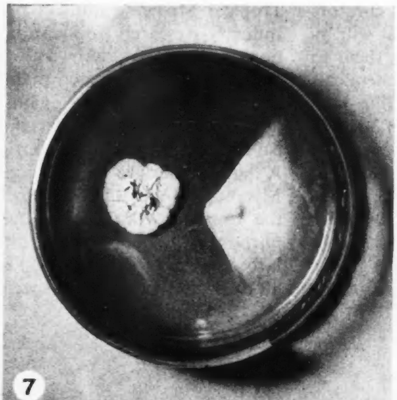
FIG. 6. A typical wood mould, *Coralloides* grow vigorously until they resemble a snowy landscape in their flask.

FIG. 7. Mould on the left is *Streptomyces hygroscopicus*, which causes a skin infection; on the right is the antidote prescribed by the central office, another mould which defeats the infection.

FIG. 8. Packing cultures for export in cardboard cylinders.

FIG. 9. Examining samples of textiles which have been experimentally mould-proofed. Conspicuous in the right foreground is a batch of McCartney bottles, so named because they were introduced into pre-war medical use by Dr. J. E. McCartney when he was director of the L.C.C. Research & Pathology Service; they are now commonly seen in culture collections all over the world.





widely in medical services (see Fig. 9). The McCartney bottle has certain advantages: it stands solidly on its own foot, needing no racks; it is durable; it can be numbered on its cap, and thus easily found among a mass of other bottles. It has disadvantages, too, and could not replace the plugged test tube for research purposes, but in a busy culture collection it is a valuable innovation. The C.B.S. and some other collections still continue to use the plugged tube.

Between 2500 and 3000 cultures a year are sent out from Baarn to all parts of the world. The tubes are packed in cardboard cylinders, three or more of these being enclosed in a larger, outer case. A variety of packings are used by other collections, the hollow wood block still retaining much of its old popularity.

The economic importance of the fungi, of which there are some 40,000 well-defined species, is not generally appreciated. The pathogenic species which cause disease in food crops and other valuable economic plants account for enormous annual losses, difficult to compute in terms of money, and their control by chemical, biological and genetical methods demands the untiring efforts of a world army of mycologists, plant pathologists and geneticists. Many other fungi cause troublesome and often incurable and fatal diseases of man; these diseases are most serious in the tropics, though in temperate climates they are not unimportant—ringworm, thrush, 'athlete's foot' and some kinds of eczema are caused by fungi. Farm stock and domestic animals, too, are subject to several serious mycoses. Other fungi cause very serious economic losses by spoiling all kinds of raw organic materials and stored foodstuffs; other species affect manufactured goods, including textiles, leather, paint, cordage, military equipment, electronic and optical apparatus. Experience during the last war focused attention on these problems, and now manufacturers in a great variety of trades regularly protect their products with appropriate fungicides.

Other fungi are useful to man: the antibiotics provide familiar examples, and several of them, such as penicillin, are derived from the metabolism of moulds. There are a number of other species, industrial strains of which make it possible to produce complex organic chemical substances which either cannot be made at all by chemical techniques or which cannot be prepared at a sufficiently low cost by completely synthetic processes. Citric acid is manufactured in this way by particular strains of *Aspergillus niger*, and examples of other substances manufactured with the aid of moulds are amylase, diastase and gluconic and lactic acids.

Not uncommonly, mutations occur in cultures, introducing a further complication for the vexation of curators of collections. Mutations can also be produced at will by bombarding cultures with electrons, by exposing them to ultra-violet radiation, or by treating them with chemicals such as mustard gas. By such means the penicillin production of some strains of *Penicillium notatum* and *P. chrysogenum* has been improved. Usually, however, the destruction of genes caused by these treatments results in deficiencies and degeneration. Even defective strains have been turned to useful purposes. Mutants of *Neurospora crassa* and *N. sitophila* created artificially are unable to make for themselves some of the vitamins of the B group, without which they cannot develop, and consequently they can only grow on media containing the relevant vitamins. The physiologist makes use of these mutants in the assay of minute quantities of vitamins in small samples of, for example, body fluids. A known quantity of the sample is added to a fluid culture medium which contains no trace of the vitamin in question, and the mixture is inoculated with the appropriate *Neurospora* strain. Growth ensues until the vitamin has been used up, and then ceases; the dry weight of the mycelium which has been formed is proportionate to the weight of the vitamin which was present. By somewhat similar techniques other fungi can be used to obtain rapid and sufficiently accurate information much more easily than could be done by chemical analysis. Thus strain 'M' of *Aspergillus niger* enables the soil chemist to estimate the quantities of the trace elements copper, manganese and zinc in soil samples.

These facts indicate the value to research workers and industrialists of culture collections from which can be obtained strains of fungi of recorded history or with particular biochemical characteristics. The uses of industrial and assay strains have been mentioned. Manufacturers who proof their products against mould damage use standard sets of fungi to test the efficacy of their treatments, inoculating samples which are then incubated in warm damp chambers with thermostatic and hygrostatic controls. Pathologists require cultures of known identity to compare with the organisms they isolate from diseased crop plants, or animal or human patients. Mycologists engaged in research on the development of fungi or studying the taxonomy of groups often need cultures of authenticated origin for comparative purposes. In the service of education, culture collections supply to schools and colleges the living fungi required for practical work in biological course, and very large numbers of cultures are sent out every year for this purpose.

All these and other needs are supplied by Holland's Centraalbureau and by similar institutions in other countries. In the United States the American Type Culture Collection at Washington is a large public collection, and some divisions of the U.S. Department of Agriculture have important collections; a notable example is that of the North Regional Research Laboratory at Peoria, Ill. In Britain the largest collection is that of the Commonwealth Mycological Institute, at Kew, which supplies fungus cultures of taxonomic, pathological, industrial and educational interest. There are specialised collections at the Forest Products Research Laboratory (timber-rotting fungi), the London School of Hygiene and Tropical Medicine (human pathogens), and the Brewing Industry Research Foundation (yeasts). All these institutions co-operate closely with one another by exchanging cultures. The duplicated maintenance of valuable strains is regarded as insurance against loss through accident.

At Baarn the staff undertake the identification of fungi isolated by mycologists who lack the necessary facilities. A similar service is provided by the Commonwealth Mycological Institute for official mycologists throughout the Commonwealth. The Institute is equipped for this purpose with a staff of consultant taxonomists, a particularly fine reference collection of herbarium material from all over the world, and a specialised library.

TERRITORY AND BIRDS

A concept which originated from study of an extinct species

EDWARD A. ARMSTRONG

Eliot Howard's book *Territory in Bird Life* (1920) gave new interest and excitement to the study of birds because the territory theory provided a clue by which much that was hitherto obscure could be interpreted. The function of song as a form of signalling whereby females were attracted and males warned off became clear. It was realised that fighting among birds was mainly for a piece of land rather than for a mate and that defence of an area, usually associated with nesting, was of great importance in bird life and tended to secure a favourable dispersal of members of a species. Ever since Howard's book appeared the territory theory and its significance have been actively discussed. Indeed so much interest has the concept of territory aroused that a good deal of research has been devoted to tracing the earliest references to it. Writers have pointed out, for example, that Aristotle noted the establishment by eagles of hunting areas and that Zenodotus remarked that two European robins would not tolerate each other in the same bush. Olina, in 1622, showed that he realised the relationship between song and the area defended by a bird, and Baron von Pernau (1660–1731) had some conception of territory. In 1772, Gilbert White had noted the 'jealousy' of male birds as tending to distribute them over the countryside and two years later Oliver Goldsmith wrote that "small birds mark out a territory to themselves, which they will permit none of their own species to remain in". The essentials of the territory concept were set forth by Altum in 1868, and other nineteenth-century writers, such as Naumann and Hantzsch, understood the significance of birds' defence of the nesting area. Moffat in 1903 wrote what may be fairly described as the first scientific paper on the subject.

Despite extensive historical research into the origin of the concept of territory, attention has not been called to a description of territorialism which was published some two centuries before the writings of Moffat and Howard and which appears to be easily the first in which most of its main characteristics received comment.

From 1691 until 1693 a few Huguenot refugees lived on Rodriguez, an island of about thirteen square miles in the Indian Ocean 334 miles from Mauritius. They were the only human inhabitants and although they called it a "desert island" they found plenty to eat and drink there. Eventually lack of female society induced them to set sail for Mauritius where they were cruelly treated by the governor. One of their number, Francis Leguat, wrote a narrative, published in London in 1708, which included an account of the Solitaire *Pezophaps solitarius*, the odd flightless pigeon related to the Dodo, which they found on the island. The remarks of other travellers and examination of the plentiful remains dug up in caves confirm details of his story and there is no doubt that it is, apart from a few minor details, an accurate account of the bird and its behaviour.

Solitaires were somewhat goose-like, elegant and stately, with fine, carefully preened plumage. Their necks and legs were long. The females stood about 2 feet 3 inches high, some 6 inches less than the males. In the English version of 1708 we are told that they "are wonderfully beautiful, some fair, some brown. . . . They have two Risings on their *Craws*, and the feathers are whiter than the rest, which livelily represents the fine neck of a Beautiful Woman." The translator was evidently something of a Mother Grundy for in the French the word used is not 'neck' but 'bosom'.

The nest of the Solitaire, in which one large egg was laid, consisted of a pile of palm leaves 18 inches high on a clear space of ground. The birds would not allow other individuals of their own species within a radius of 200 yards of the nest. This is the only exact estimate of territory, so far as I am aware, until the present century. Leguat does not use a term precisely equivalent to 'territory' but he speaks of limits' and 'bounds' to the defended area, making it quite clear that the concept was in his mind. Moreover, he emphasised that male fought male and female fought female in defending the area. Only during this century has it been realised that this is common among birds. He states that if an intruding female appeared, the male Solitaire would call his mate to deal with her while an intruding male was always attacked by a bird of his own sex. As male and female differed so much in size Leguat could easily distinguish one from the other. He makes no reference to birds ever being driven from their territories by intruders, so perhaps he implicitly recognised the dominance which possession of territory tends to confer.

The most remarkable aspect of the Solitaire's defence of territory has yet to be mentioned. On the wing joint was a bony knob "the size of a musket ball". For periods of four or five minutes at a time a bird would perform twenty or thirty rapid pirouettes, whirling its wings with a rattling noise which could be heard 200 yards away. This distance, it will be noted, is the same as the estimated radius of the territory—indicating a correlation between the defended area of the bird's mechanical song. The Solitaire's wings,

no longer useful in flight, had become adapted to serve as musical instruments and weapons. Birds such as jacanas and spur-winged lapwings bear 'spurs' on the wing joints which, presumably, are conspicuous during threat display but the armature of the Solitaire was more elaborate. The Dodo, however, also had a thickening of the wing bones. It is well known that wood pigeons and domestic pigeons will buffet each other with their wings so that these extinct species obviously evolved still further along lines already adopted by members of the family to which they belonged. So many of the Solitaire's fossil bones were found to have been broken and united again during life that although Leguat does not mention the birds belabouring each other during territorial quarrels there can be no doubt that they sometimes did so.

Leguat says that the Solitaire's wings were used to beat itself and "faire le moulinet". Species such as the pheasant and ruffed grouse flap their wings to make a loud noise proclaiming their possession of territory, but Leguat's phrase suggests the rapid movements of a swordsman defending himself on all sides. He makes it clear that the clattering of these armed wings was effective in attracting the female as well as in defying rivals. Boundary quarrels were frequently protracted as the intruder, when menaced by the owner of the ground, would only retreat a few paces and turn back again, but the proprietor would persist until the trespasser was finally driven off. Perhaps Leguat's description implies a 'back and forth' series of movements such as is most conspicuously illustrated by the 'pendulum' flights of male prairie horned larks over a disputed boundary.

The Solitaire maintained territory during incubation and until the chick became independent. As incubation lasted seven weeks and the young bird was under parental care for some months, territory may have been defended throughout most of the year. This would be consistent with the emphasis which writers place on the non-gregarious habits of Solitaires. Thus Leguat begins his description with the words: "Of all the birds in the Island, the most remarkable is that which goes by the name of the Solitary, because 'tis very seldom seen in Company, though there are abundance of them." Thus the name of the bird perpetuates the conspicuousness of its territorial behaviour.

Discussion still continues as to the food-values of territory but it is generally agreed that the freehold, if it is more than a location for the nest or a display stance, is often important as an area in which food for the young may be obtained. The Solitaire's territory was valuable as a foraging ground. Apparently the nest was in the centre of the defended area. Evidently population pressure was considerable, and suitable areas were divided into contiguous territories. The birds fed on fruit, seeds and fallen leaves. Leguat, who evidently had a soft place in his sentimental heart for the Solitaire, says that he and his companions left the fruit of some of the palms for them to eat. Would that other early explorers of oceanic islands had been equally considerate in regard to the welfare of the birds they found on them! Two such large birds, with a growing chick, would require a great deal of food so that the value to them of a private foraging ground is obvious.

There is only one section of Leguat's narrative in which his sentimentality obscures the facts so much that it is difficult to decide the significance of what he describes. He says: "We have often remarked that some days after the young one leaves the nest a Company of thirty or forty bring another young one to it. The fledg'd Bird with its Father and Mother joyning with the Band, march to a Bye Place. We frequently followed them and found that afterwards the old ones went each their own way alone or in Couples and left the young ones together, which we called a Marriage." He then rambles on into a disquisition about the advantages of early marriage in human society and we are left to make what we can of this description. Presumably after the breeding season territory was temporarily abandoned, flocking occurred and the pairing-up of the young took place in the flock. Leguat points out that even when Solitaires associated in a group they remained paired.

Professor Alfred Newton, the great Cambridge ornithologist of the latter half of the nineteenth century, was particularly interested in the Solitaire because his brother, Sir Edward Newton, held the post of Auditor-General of Mauritius and himself dug up some bones of the bird. They collaborated in a paper read to the Royal Society in which they set forth the theory that the Solitaire was polygamous, confessing, however, that the problem of the nature of its pair-bond was not likely to be solved. Their argument was based on the disparity in size of the sexes and the pugnacity of the birds. However, there can be considerable differences in the size of the sexes without polygamy, as among steamer ducks. Moreover, Leguat's observations show clearly that Solitaires were not polygamous. He states that both birds incubated and tended the chick; moreover the territorial system he describes would be incompatible with polygamy. Among the doves and pigeons monogamy is the rule. Although Newton was a paragon of accuracy he was mistaken in another minor matter. He thought that between the time of Leguat and later observers the birds had learnt to resent ill-treatment by biting. It is true that an unidentified writer somewhat later than 1730 says that they bit when hard pressed, but Leguat had already noted that the bird's beak as well as its wings were used in defence.

We may sum up thus the information which Leguat gives in regard to the Solitaire's territorial habits:

1. An area within certain boundaries is defended.
2. The area is approximately of 200 yards radius.
3. It is defended by both sexes.
4. Male defies male, female defies female.
5. Instrumental 'song' is used to intimidate intruders.
6. The 'song' is also used to attract the female.
7. Defence of the territory is maintained during incubation and until the young attains independence.
8. It is implied that the defended area is the foraging area.
9. Pair-formation takes place outside the territory.

Thus Leguat's account is the earliest detailed description of territory. It is strange that the first man to have paid attention to these facts of behaviour, now realised as being typical of many species, should have been a non-ornithologist on a 'desert island' observing a bird which has now become extinct.

Far and Near

Night Sky in July

The Moon.—New moon occurs on July 11d 02h 28m, U.T., and full moon on July 26d 12h 20m. The following conjunctions with the moon take place:

July			
7d 13h	Venus in conjunction with the moon	Venus	8° S.
8d 11h	Jupiter ,,	Jupiter	5° S.
12d 15h	Mercury ,,	Mercury	3° S.
19d 01h	Saturn ,,	Saturn	8° N.

The Planets.—At the beginning of the month Mercury sets at 21h 30m and may be just glimpsed for a short time after sunset but is drawing closer to the sun; it is in inferior conjunction on July 25 and for the greater portion of the month cannot be seen. Venus, a morning star, rises at 1h 30m on July 1 and about 1h 10m at the middle and end of the month. Its stellar magnitude averages $-3{\cdot}7$ and the visible portion of its illuminated disk varies from 0·54 to 0·67. Mars is too close to the sun during most of the month to be seen; on July 31 it rises at 3h 35m—less than 40 minutes before sunrise but is still too close to the sun for observation until August. Jupiter rises at 2h 05m, 1h 20m and 10h 30m on July 1, 15 and 31, respectively, and is visible for some time before sunrise in the constellation Taurus. Saturn sets at 0h 15m, 23h 20m and 22h 20m at the beginning, middle and end of the month, respectively, and is visible in the constellation Virgo N. of Spica, stellar magnitude about 1. The rings are well placed for observation.

There will be a partial eclipse of the sun on July 11 and a total eclipse of the moon on July 26, but as neither of these eclipses is visible at Greenwich it is unnecessary to give any details about them, except to add that the eclipse of the moon is visible over large portions of North and South America, the north-eastern parts of Asia, Australia, the Pacific and Indian Oceans.

Controlled Ripening of Bananas

Among the gases liberated when bananas are ripening is ethylene, produced at a rate of 100–200 milligrams per ton of bananas. This gas actually stimulates the ripening process, with the result that once the gas is produced by a few bananas in a cargo of the green fruits the ripening process spreads rapidly almost as though it were an infection. Ordinarily bananas that start ripening in the course of sea transport are removed. Britain's D.S.I.R. has been investigating this matter in Jamaica, and experiments were carried out for the purpose of discovering methods of suppressing the generation of ethylene. It was found that a small quantity of ozone had the desired effect, and the start of the ripening process was delayed by twenty days, which exceeds the length of voyage made by banana boats travelling from the West Indies to Britain. In this way losses due to premature ripening could be prevented. After arrival in Britain, such banana cargoes could be made to ripen speedily by dosing them with—ethylene!

I.C.I. Chairman to Retire

A scientist has become chairman of the Board of Imperial Chemical Industries in succession to Mr. John Rogers. He is Dr. Alexander Fleck, who has been actively associated with the company and its predecessors since 1917, and was appointed to the Board of I.C.I. in June 1944.

Dr. Fleck studied chemistry at Glasgow University from 1907 to 1911. He then became an assistant in the Physical Chemistry Department of the University for two years and later served on the Glasgow and West of Scotland Radium Committee as a physical chemist concerned with radiological research work on cancer. Dr. Fleck joined the Castner-Kellner Alkali Co. in 1917, and in 1931 he became managing director of what is now I.C.I.'s General Chemicals Division. In 1937 he was appointed Chairman of Fertiliser and Synthetic Products Ltd. (now I.C.I.'s Billingham Division). He went to the I.C.I. Main Board in 1944 and until his election as a deputy chairman he was the director responsible for Billingham and Central Agricultural Control. In 1946, the Wilton project was added to his responsibilities.

I.C.I.'s Titanium Plant

I.C.I. has announced that a plant is being erected to produce 100 tons per annum of wrought titanium metal, which will provide sufficient material for prototype applications by customers in the engineering and aircraft industries. At the same time active consideration is being given to the design and construction of a much larger plant, to produce some 1500 tons per annum of titanium metal in sponge form and to convert this by melting to massive metal.

N.C.B. Director of Extramural Research

Mr. A. Whitaker, O.B.E. has become Director of Extramural Research in the National Coal Board.

In addition to their own research establishments at Stoke Orchard and Isleworth, the N.C.B. have extensive research interests in several Research Associations and also sponsor projects at a number of universities and with commercial firms. This work is now directed by Mr. Whitaker who is responsible to the Director-General of Research at Headquarters, Dr. W. Idris Jones.

Mr. Whitaker, who is 52 and a physicist, was educated at Tonbridge School and Emmanuel College, Cambridge. During the war he was with the Parnall Group of Companies and was awarded the O.B.E. for his work in connexion with aircraft equipment.

Knighthood to Dr. Bullard

Among the knighthoods announced in the Coronation Honours List was that of Dr. Edward C. Bullard, director of the National Physical Laboratory. Other new knights from the world of science and technology include Sydney Camm, director and chief designer, Hawker Aircraft Ltd.; Enoch B. Levy, formerly director of the Grassland Division, Department of Scientific and Industrial Research, New Zealand; George D. A. MacDougall, chief adviser, Statistical Branch, Office of the Paymaster-General; Charles R. Morris, vice-chancellor of the University of Leeds; Thomas O. M. Sopwith, for services to aircraft production; Dr. Francis M. R. Walshe, president of the Royal Society of Medicine.

New Fellows of the Royal Society

This year's list of new Fellows of the Royal Society contains twenty-five names. They are as follows:

DR. J. S. ANDERSON, deputy chief scientific officer, Atomic Energy Research Establishment, Harwell, distinguished for his contributions to inorganic chemistry, particularly in connexion with the chemistry of the metal carbonyls, complex salts and non-stoichiometric compounds.

DR. KENNETH BAILEY, assistant director of research in the Department of Biochemistry and Fellow of Trinity College, Cambridge, distinguished for his biochemical researches on the proteins of muscle.

PROF. H. BARCROFT, professor of physiology, Sherrington School of Physiology, St. Thomas's Hospital, London, S.E.1, distinguished for investigations respecting the blood supply to human muscles.

DR. J. BARKER, reader in plant physiology, University of Cambridge, distinguished for investigations on the carbohydrate metabolism of plant storage tissues.

DR. J. C. BURKILL, university lecturer in mathematics, University of Cambridge, distinguished for his researches in analysis, especially in the theory of integration, also for his contributions to the theory of trigonometrical series.

DR. J. W. CORNFORTH, research chemist, National Institute for Medical Research, distinguished for his fundamental contributions to the chemistry of penicillin and its degradation products, to the chemistry of the oxazole group, and for the total synthesis of the androgenic hormones.

DR. S. C. CURRAN, senior lecturer, Department of Natural Philosophy, University of Glasgow, distinguished for his contributions to electronic counting techniques, and for his researches upon the emission of β- and γ-rays by atomic nuclei.

New Fellows of the Royal Society

DR. KENNETH BAILEY

PROF. HENRY BARCROFT

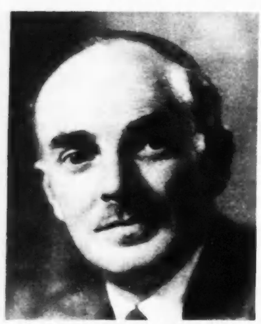
DR. J. W. CORNFORTH

DR. S. C. CURRAN

A. A. HALL

PROF. G. W. HARRIS

SIR CLAUDE INGLIS

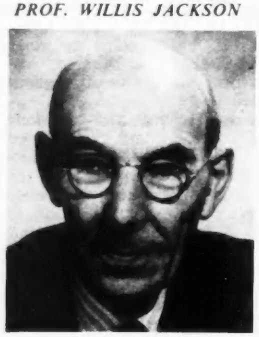


PROF. WILLIS JACKSON

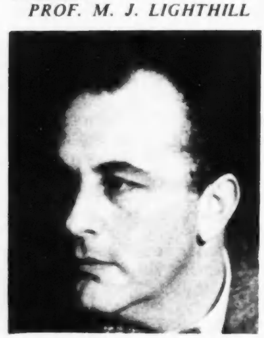
PROF. M. J. LIGHTHILL

DR. G. H. MITCHELL

PROF. L. S. PENROSE



A. R. POWELL



LORD ROTHSCHILD

PROF. T. WALLACE

C. S. ELTON, director of the Bureau of Animal Population, Oxford, distinguished for his pioneer work in the field of animal ecology as founder of the Bureau of Animal Population and of the *Journal of Animal Ecology*.

DR. O. H. FRANKEL, chief of the Division of Plant Industry, Commonwealth Scientific and Industrial Research Organisation, Australia, distinguished for his combined genetical and cytological studies on economic plants.

DR. E. F. GALE, reader in chemical microbiology, University of Cambridge, distinguished especially for his work on the amino-acid metabolism of bacteria and the effect thereon of penicillin and other chemotherapeutic agents.

DR. A. G. GAYDON, Warren Research Fellow of the Royal Society, Imperial College of Science and Technology, London, distinguished for his researches on the spectra of flames, which have gone far in elucidating the mechanism of flame reactions under the most varied conditions.

A. A. HALL, director of the Royal Aircraft Establishment, Farnborough, distinguished for his contributions to the theory and design of aircraft and their equipment.

PROF. G. W. HARRIS, Fitzmary professor of physiology, Institute of Psychiatry, University of London, distinguished for his contributions to the physiology of the hypothalamus and pituitary body.

SIR CLAUDE INGLIS, director of hydraulics research, Department of Scientific and Industrial Research, distinguished for his pioneer work in studying hydraulics by the use of scale models, and for the application of these techniques to hydraulic problems in India.

PROF. WILLIS JACKSON, professor of electrical engineering, Imperial College of Science and Technology, London, distinguished for his studies of the electrical behaviour of dielectrics and of the performance of transmission lines and waveguides. (Prof. Jackson's appointment as Director of Research and Education of Metropolitan Vickers Electrical Co. Ltd., announced in the March issue, takes effect on July 1.)

PROF. M. J. LIGHTHILL, Beyer professor of applied mathematics, University of Manchester, distinguished for his researches in fluid dynamics, especially in non-linear problems of compressible flow, in supersonic boundary layer theory and in shock wave theory.

DR. G. H. MITCHELL, a principal scientific officer, Geological Survey of Great Britain, distinguished for his researches in palaeozoic stratigraphy.

PROF. L. S. PENROSE, Galton professor of eugenics, University of London, distinguished especially for his study of the factors responsible for mental deficiency and for inheritance studies in man.

A. R. POWELL, research manager, Johnson Matthey and Co. Ltd., distinguished for his contribution to analytical chemistry and the chemistry and metallurgy of the rarer metals which has led to important developments in methods for the extraction of platinum ores and the production of very pure metals.

DR. H. M. POWELL, reader in chemical crystallography, University of Oxford, distinguished for his elucidation of problems of chemical constitution by X-ray methods especially of organo-metallic and clathrate compounds.

LORD ROTHSCHILD, G.M., assistant director of research in the Department of Zoology, University of Cambridge, distinguished for his investigations into the process of fertilisation and the physiology of reproduction. (Lord Rothschild is the present chairman of the Agricultural Research Council.)

DR. D. SHOENBERG, reader in physics, University of Cambridge, distinguished for his researches in the field of low temperatures, especially upon superconductivity and the magnetic properties of metals.

PROF. T. WALLACE, professor of horticultural chemistry, University of Bristol, and director of the Horticultural Research Station, Long Ashton, distinguished for his studies of mineral nutrition of horticultural crops especially in respect to diagnosis of deficiencies.

PROF. D. WHITTERIDGE, professor of physiology, University of Edinburgh, distinguished especially for his studies of the nerves of thoracic viscera and of the external muscles of the eye.

DR. R. VAN DER R. WOOLLEY, director of the Commonwealth Observatory, Australia, distinguished for his work on the formation of absorption lines and on convective processes in the solar atmosphere.

Antibiotics and Plant Growth

ANTIBIOTICS have a stimulating effect on the growth of plants, according to a paper by Dr. L. G. Nickell in the *Proceedings of the Society for Experimental Biology and Medicine* (Vol. 80, No. 4).

It has been known for some years that minute quantities of antibiotics such as penicillin and terramycin stimulate the growth of poultry, hogs and other animals, bringing them to market weeks sooner, on less feed. Almost nothing was known, however, of the effect these same antibiotics might have on plant growth before Dr. Nickell announced the result of his experiments.

He experimented mostly with a variety of maize. In one experiment he planted forty-nine seeds in each of two greenhouse flats. One flat was watered once each day for four days with one litre of tap water containing five parts terramycin per million parts water, and thereafter as needed. The seeds in the second flat were given the same amount of water, but without any antibiotic. Growing conditions were identical.

After four weeks, the maize was removed from the soil, weighed and measured. The average height of the corn given terramycin was 44·32 cm. compared with 35·56 cm. for the untreated corn. The tallest treated plant was 60·96 cm. and the tallest untreated 49·53 cm. The shortest treated plant was 24·77 cm., contrasted with 15·24 cm. for the smallest untreated plant.

Dr. Nickell found that the maize above ground in the flat given terramycin weighed 45 gm. wet, while that in the untreated flat weighed 23 gm. Then, plants of both groups were dried separately at 105° C and weighed again. The treated group weighed 5·1 gm. dry, the untreated 2·4 gm. Hence it was concluded that the gains represented were true growth responses and not due to increased water absorption.

Moreover, of the forty-nine sweet-corn seeds planted in the treated flat, twenty had germinated and formed plants. Of these in the flat not given antibiotic, only twelve had germinated.

Similar results were obtained with sorrel and radish.

Progress on the Atomic Submarine

The U.S. Atomic Energy Commission recently released a few facts about the progress of the atomic-powered submarine project at Schenectady. Known as SIR for Submarine Intermediate Reactor, this project is controlled by the Knolls Atomic Power Laboratory at Schenectady, which is operated for the A.E.C. by the General Electric Company. Development of the site at West Milton, eighteen miles north of Schenectady, has now reached the stage where the foundations for the giant sphere in which the experimental reactor and the land-based prototype submarine are to be housed have been completed.

These foundations are in the form of a large concrete saucer 176 ft. in diameter and 42 ft. deep. The sphere itself, which will rest in the saucer, will be made of welded steel plates and will be 225 ft. in diameter, is designed to give extra protection to the operating personnel. If any radiation should leak through the reactor shield, it will be held within the sphere and diluted to a relatively safe level by the huge amount of air (5,400,000 cu. ft.) the sphere contains. Further precautions to avoid radioactive contamination of the atmosphere included the passage of the radioactive air from the plant through a caustic scrubbing unit and especially designed high-efficiency filtration system which, it is claimed, removes 99·9% of the radioactive materials. After this treatment the air is further diluted by from 1000 to 10,000 times by mixing with clean filtered air before being discharged from the 100-ft. stack. The steel plates of which the sphere is being built are being hauled into position by a derrick mounted 424 ft. above ground level and each is being carefully X-rayed to make sure there are no cracks through which radiation might leak. The hull of the submarine itself is being assembled outside the sphere, and when finished it will then be slid inside the sphere before the last metal plates are joined together. Liquid sodium metal is to be used to take the heat from the reactor core to the heat-exchanger, and then the heat will be used for raising steam in a marine turbine boiler of orthodox type.

Atomic Energy in Sweden

Sweden, which lacks sources of uranium, has developed special techniques to extract the small quantities of uranium which occur in her large shale beds. The uranium concentration in the shale itself is about 200 gm. per metric ton, but the shale also contains lumps of a material called kolm which contains up to 3000 gm. of uranium per ton. The Swedes are building a plant at Kvantorp for the extraction of kolm from the shale, and also intend to extract uranium from both shale and kolm at Kvantorp. The final refining processes will be carried out at the atomic energy plant in Stockholm.

Sweden's first reactor is being built in the middle of Stockholm itself. This is possible because it is being constructed in a special underground laboratory hewn out of the bedrock on which the city stands. The pile itself which should be complete and ready for operations by the end of this year will be a low-powered 100-kW reactor using 3–4 tons of uranium and cooled by air. The moderator will be heavy water from Norway. A second power reactor of 10,000–20,000 kW is already being planned as part of the next ten-year programme.

Britain's Atomic Exports

BRITAIN is now the largest exporter in the world of radioactive materials for peaceful purposes. The only other competitors in the world market for these materials at present are the United States and Canada.

Owing to the growing urgency of demands from far-away countries, B.O.A.C. have converted a fleet of Argonauts to carry the materials in their wing-tips and are now considering suggestions for similar modifications to Comet 2 aircraft. This method reduces the cost of transport by over 60% by cutting out the cost of heavy lead containers.

During last year the Supply Ministry's Atomic Research Establishment at Harwell sent more than 3000 consignments of isotopes to no fewer than thirty-seven different countries.

Radioactive isotopes are still used mainly for medical purposes and new discoveries are continually being made to increase their scope; but they are also daily gaining more significance in scientific research and industrial applications. In this country there is hardly one industry which is not using these new 'tools' of science in one form or another.

Altogether 9578 consignments were sent from Harwell in the year, of which 3053 went overseas by air.

Miniature Jet Starts Bigger Jets

A MINIATURE jet starter motor, only a few inches long, which fits inside aircraft jet engines, is being developed by British experts; its job is to get the big jet engine turning over at several thousand revolutions a minute from a cold start in a few seconds.

Existing jet fighters and bombers have a cartridge starter which explodes and gives the gas-turbine engine a powerful turn. But the cartridge has limitations which have been overcome in this new starter, which uses a liquid fuel. The liquid starter is a miniature gas-turbine, basically a combustion chamber and a turbine and shaft. The fuel used is propyl-nitrate. Under combustion it produces power to drive the miniature turbine. This is geared to produce up to 10,000 revolutions per minute on the shaft. The liquid starters are being developed by three British companies.

LETTER TO THE EDITOR

Dr. Lilley's reply to Dr. Crombie's Criticisms

Sir,

No reviewer being perfect, Dr. Crombie may be right in thinking that I misunderstood the general intention of his book, *Augustine to Galileo*. I feel, however, that he has misinterpreted the intention of my review. I did not, for example, attribute Galileo's method to "nothing but the play of sociological forces". On the contrary, I believe that the history of science can only be understood by considering the *inter*play of both internal scientific development and the influences of ambient social change.

I agree, of course, that the author devoted several pages to the very important mathematical aspects of Galileo's method, and fully stressed their novelty. However, my review referred explicitly to Galileo's "method of testing hypotheses by comparing deduced consequences with experiment", which (as Galileo clearly saw) has a logic independent of whether mathematics is or is not the deductive instrument. Crombie claims that this method of hypothesis-testing was created in the 13th century and merely taken over by Galileo. If this claim is only hinted at in the book under discussion (e.g. pp. 271 and 273), it is stated explicitly in the author's *Robert Grosseteste* (p. 9).

Now I fully agree, and I stated in my review, that the medieval methodologists provided one source of Galileo's achievement. But I differ from Crombie in believing (*a*) that the best medieval work fell short of Galileo (even apart from the mathematics), and (*b*) that even this best was not available to Galileo, who derived this side of his thought from the diluted and abstract methodological discussions of the Paduan school. In my view Galileo's success depended on his blending of this tradition with another one—that derived from the *unmethodical* experimenting of advanced 15th- and 16th-century artists, engineers, instrument makers, etc.—craftsmen, not scholars. Galileo combined the two streams; and he was able to do so, because 17th-century social conditions brought scholar and craftsman closer together than ever before. I cannot see how this view, involving both a scholarly tradition and a social change, can be called an "exclusively sociological thesis". Nor does it justify Crombie's penultimate paragraph. The practical men, the Leonardos, Tartaglias and Stevins, were not educationally equipped to make methodological advances. That needed the scholars, primarily interested "in the *understanding* of observations", such as for Gilbert, Galileo and Bacon—but it also needed conditions which opened their eyes to the value of the empiricism in which academic thought was weak.

This thesis involves, of course, many questions that need further research—that is why I introduced it with the modest phrase, "There is a good deal of evidence to show", which was no doubt the cause of Crombie's accusation of "most misleading conviction". There is, to begin with, the problem of transmission from the 13th to the 16th centuries, on which, I agree, "much basic research has yet to be done". Hence my feeling that the author would have done better to stop with the 13th century instead of trying to leap the fence through which monograph writers are still learning to crawl. But the existing evidence suggests that the best medieval work was not so much actively transmitted as put into storage from which 16th-century investigators could retrieve it when, in new conditions, they found a use for it. The work of Theodoric of Freiburg, whom Crombie cites as the best example of medieval experimental method, was not even printed till this century, though certainly manuscript copies had occasional influence (see Crombie's *Grosseteste*).

"No amount of special pleading" can show more than an intermittent and weak interest of 13th-century scholars in the *crafts* (as contrasted with non-craft practical matters like calendar reform or medicine). And in neither of his books does Crombie produce any *evidence* that craft contacts influenced scholarly methodology in that period (though some might have been adduced for Peregrinus). By contrast, while the interest of, say, Galileo in technology was not so great as some writers (*not* the reviewer) "would seem to believe", we have that scholar's glowing acknowledgment of what he learnt from the artisans of the Venetian arsenal, and his explicit statement that he hit on an acoustical experiment by accident while filing a piece of brass in his own instrument-making factory. Thus, while the evidence is incomplete in many ways, it does tend to show that Galileo derived experimental practice from craft contacts, quite as much as he derived methodological theory from the tradition of scholarly ratiocination. History has not got a one-track mind.

S. LILLEY

THE BOOKSHELF

Radiations and Living Cells (Frontiers of Science Series) by F. G. Spear (*London, Chapman and Hall, 1953, 222 pp., 18s.*)

Within the last twenty years this country has led the world in making physicists an integral part of the practice of hospital medicine in the field of radiotherapy, and it does not seem likely that their influence will stop there. But if people with such different backgrounds as physicians and physicists are to have a mutual understanding of what they are doing they must learn a good deal of each other's language and ways of looking at things. Dr. Spear has exceptional qualifications for this task of interpretation. His book is dedicated to the Hospital Physicists' Association, but little of it is medical (in the narrow sense) and all of it should be easily intelligible to readers without special biological training whether they are physicists or not. Half the illustrations and a quarter of the letterpress are devoted to the anatomy and physiology of cells and tissues and the biology of cancer, each biological section leading naturally to a discussion of radiation effects. Atomic warfare is briefly discussed; radiology as a diagnostic tool and the use of isotopes as tracers are not. The historical parts are very well done and the book opens and closes with most apt citations from Thomas Sprat (1702) on the value of 'pure' research.

One major criticism may be made. The magnification of the illustrations of microscopical preparations is never given, and this seems especially unfortunate in a book designed for readers unfamiliar with the originals. There are also a few errors, e.g. pp. 96 and 101, erythroblast should be erythrocyte; p. 133, 10^{13} should be 10^{12}; p. 170, $\frac{1}{10}$r daily surely does not reduce the life span even in mice. The price may seem a little high but the illustrations are numerous and well produced.

R. H. MOLE

Estimation of Organic Compounds by F. Wild (*London, Cambridge University Press, 1953, 239 pp., 25s.*)

In his previous book, *Characterisation of Organic Compounds*, Dr. Wild provided a very useful comparative survey of the methods used to prepare derivatives of organic compounds essential in their identification, and has followed this up by the present volume on quantitative analysis.

There has been a definite need for a book of this type. Although the methods he discusses are quite well known, the quantitative aspect of practical organic chemistry tends to be overlooked in reference and text-books, and one has often needed either to work out the method when needed or to consult original papers and scattered sources. The variation in accuracy of results has undoubtedly been mainly responsible for this omission, and here the author helps by giving limits of accuracy for the various methods he quotes. Organic estimations have been given too little place in the training of chemists, and it is to be hoped that those responsible will find this book a help, and an incentive to fill the gap.

Among compounds and groups included are olefines, alcohols, enols, phenols, mercaptans, aldehydes and ketones; acetyl, benzoyl, methoxyl, ethoxyl, propoxyl, butoxyl, methylimino, ethylimino; methyl and ethyl groups attached to sulphur; the methyl group attached to carbon; amines and amino compounds; nitro, nitroso, cyano; isocyanates and isothiocyanates. In fact most of the cases likely to be encountered frequently seem to be included; specialised methods or techniques, ultimate analysis and molecular weight determinations are omitted. Adequate references are given, and the author has wisely done so on the appropriate pages rather than at the end of each chapter which is inconvenient.

The book is well printed, but there is a tendency to cramp chemical equations, quite unnecessarily in many cases. This is particularly noticeable where ring structures or structural formulae are used, the = sign being so close that it appears to be a double bond.

This book should find its way on to the bookshelf of every practical organic chemist, teacher and college library. Dr. Wild seems to have attempted not so much to give full details of the methods in use—although in many cases these are adequate except for such things as preparation of catalysts—as to provide a link for the worker with the primary and secondary literature sources, and to discuss the suitability and limitations of the various methods available. If this is his main purpose, he has succeeded admirably.

A.B.A.

Robert Grosseteste and the Origins of Experimental Science 1100-1700 by A. C. Crombie (*London, Oxford University Press, 1953, 369 pp., 35s.*)

This book is an attempt to evaluate the influence of Grosseteste, outstanding Oxford scholar of the early 13th century, and of his successors up to about 1310, on the development of scientific method, particularly the key method of testing hypotheses by comparing deduced consequences with experiment. It is a scholarly work, not one of popularisation, and as such may be judged chiefly on two issues: (1) the presentation of the evidence, and (2) its interpretation.

It would be hard to pick more than minor quarrels with Dr. Crombie's presentation of the evidence. He has searched deeply in the works of the authors that concern him. All key passages and many minor ones are quoted at length. In most cases the Latin original is given in a footnote, with English translation in the text. Every quotation and nearly every casual reference is documented in detail, and the bibliography covers 32 pages.

The interpretation of the evidence is more open to dispute. The author's thesis is that the experimental method which flowered in the 17th-century Scientific Revolution is in reality a product of 13th-century scholasticism—that in this period "a systematic theory of experimental science was understood and practised by enough philosophers for their work to produce the methodological revolution to which modern science owes its origin" (p. 9). It seems to the reviewer that this very wide claim, including the virtual denial that anything really novel occurred in the 16th and 17th centuries, is not justified by the evidence so fully presented. A fair interpretation, in the reviewer's opinion, would note that the medieval scholastics contributed much more than has hitherto been allowed towards the creation of the modern method. But it would also define carefully their limitations (which, though never stressed by Crombie, appear clearly in the passages he quotes). It would therefore recognise that the medieval development was only one of several equally important factors involved—others coming, for example, from the practice of progressive Renaissance artists and engineers; and that finally the combination of these several factors to create the full modern method in Galileo's time depended on social conditions unique to that period.

However, what matters essentially in this book is not the author's interpretation—which will doubtless be discussed in relation to a broader field of evidence for years to come—but rather his detailed presentation of the evidence in his own particular field. If all historians of science presented their facts so fully, then no matter how wrong their interpretations might seem to be, the path forward would be greatly smoothed.

S. LILLEY

British Scientists of the Twentieth Century. by J. G. Crowther (*London, Routledge and Kegan Paul, 1952, 320 pp., 25s.*)

This book belongs to precisely the same genre as Crowther's two earlier biographical books, *British Scientists of the Nineteenth Century* and *Famous American Men of Science*. The amount of detail it contains is most impressive, particularly to anyone with experience of collecting such material from extremely diverse sources. The six scientists whose careers are described are J. J. Thomson, Rutherford, Sir James Jeans, Sir Arthur Eddington, Sir Frederick Gowland Hopkins and William Bateson. Some idea of the prodigious effort which Crowther has put into the collection of significant facts about his subjects may be gained when one realises that in the case of J. J. Thomson and Rutherford, for instance, he has included much information which is not to be found in the official biographies. Most of the information would probably never have been recorded at all if Crowther had not done so, and posterity's understanding of the characters of these two great men would have been the poorer.

The biographies of Gowland Hopkins and William Bateson are even more valuable in so far as no conveniently available accounts of their lives and work exist, apart from a chapter on Gowland Hopkins in Ritchie Calder's *Profile of Science*.

Crowther's book aims to present something more than conventional biographies. He aims to relate the careers of his subjects to their social and economic background, and to show the way in which this affects or determines such things as their choice of research problems. In the introduction, he maintains that all six scientists with whom he is concerned in this volume "were deeply influenced by various phases of British capitalist development and imperialism". This is not perhaps a particularly surprising statement, but he follows it up by claiming that Jeans and Eddington belonged to a phase of "capitalist science in decline, and Hopkins to the socialist science of the future", while he labels Rutherford as "a democrat from the colonies who had been brought by a declining imperialism to its centre". At times this kind of Marxist interpretation of history which Crowther attempts to give proves most irritating; moreover, many readers will most probably find that a number of interpretative passages in the book detract from rather than add to their understanding of the inter-relationship of science and society. This criticism does not, however, affect the main value of the book—its richness in factual information, a high proportion of which cannot be found in any other book.

King Solomon's Ring by Konrad Z. Lorenz, with a Foreword by Julian Huxley (*London, Methuen, 1952, 199 pp., line drawings by the author, 15s.*)

Konrad Lorenz has been disparaged by some students of animal behaviour as being more of a naturalist than a true scientist. This is because he loves his animals as well as studying them. He must indeed love them to put up with all the damage and inconvenience his methods of study have involved. For to Lorenz, to study an animal is to live with it, not just to have it living with him, or in a laboratory, suitably locked in a cage on appropriate occasions. This does not mean that he went and nested with the geese and jackdaws, but it does mean that they nested with him and that, for example, he spent hours crawling around low on the ground quacking "Mallardeese" at a brood of young Mallard ducklings. For the Mallard ducklings made him their mother, and the Mallard mother habitually quacks continuously, even a break of half a minute starting the ducklings shrilly weeping. And while the looks of Mamma did not matter at all, but only the voice, the height of that voice above the ground must not be too great. Hence the need for Lorenz's uncomfortable posture.

Lorenz's book, *King Solomon's Ring*, is full of such anecdotes. Many of them show that it was not only long periods of physical discomfort and dirt and damage within the house that he had to put up with, but also the lack of understanding and hostility of the unsympathetic. Occasionally, as when repeatedly shrieking "O-ah" skyward at a distant speck flying high over Altenburg railway station in a desperate attempt to attract his cockatoo, Koka, he risked being quite literally taken for a lunatic. Luckily for Lorenz, Koka responded, and plummeted downwards to perch upon his shoulders, making explanations of his behaviour to the astonished crowd simpler, if not entirely comprehensible.

Lorenz's lengthy description of his work on the jackdaws, with which he surrounded his roof top, is, as Dr. Huxley rightly says in his foreword, "one of the most illuminating accounts ever given of the life of a social organism".

But it is not only birds that Lorenz studies with such sensitivity and comprehension; his accounts of the courtship and wars of his sticklebacks and Siamese fighting fish, and his clear and simple experiments which yield direct answers to the questions asked, show the scope of his understanding of animal behaviour.

Of course, the animals in turn understood him, like the raven that called him by wobbling its tail and using his own name "Roah", to entice him away from places it did not like. Lorenz's book is a gold-mine of such stories and full of behaviour lore. For it is a truism too often neglected and then sadly and painfully learnt, that a *sympathique* understanding of each insect and animal is a necessary concomitant for successful experimental study, whether conducted in the laboratory or the field.

If Lorenz's book may seem at first rather falsely and sophisticatedly naïve in its style, as it did to the reviewer, this feeling is soon conquered by the wealth of material and clarity of description and interpretation presented within it. As Huxley says, Lorenz has contributed much to the science of behaviour by his studies on the 'releaser' and 'imprinting' mechanisms which play so important a part in modern theories of animal psychology. There is a shrewd scientist behind the lover. And perhaps there is even something in his reinterpretation of the 26th verse of the 6th chapter of St. Luke's Gospel—"and unto him that smiteth thee on the one cheek offer also the other"—although even Lorenz has to admit that while it may work for wolves (complete surrender by one wolf with the presenting of its jugular vein for biting, inhibiting all further attack from the other), it does not yet for man. Man has made, not grown his weapons, and has therefore lost the safeguard of species-preserving inhibitions.

DEREK WRAGGE MORLEY

A Day with the Film Makers by Francis Rodker (*London, Pitman, 1952, 68 pp., 10s. 6d.*)

This is a children's book which explains how films are made, and describes the technical processes involved in their shooting, sound recording, projection, etc. It is written in the form of a dialogue between two children and their uncle, and should therefore please the readership for whom it is intended. It is well illustrated, with photographs which are not just ordinary film stills but have been selected to make more realistic the descriptions of the various technical tricks of the trade. The author's own diagrams are first-class, as one would expect from the man who is responsible for animation and special effects for the Shell Film Unit.

Vivarium Life by Alfred Leutscher (*London, Cleaver-Hume Press, 1952, 230 pp., 15s.*)

Hardly anyone in Britain has greater experience of keeping amphibia and reptiles, native and foreign, than Mr. Leutscher, and this book can be recommended to all who need practical information about the kind of conditions that are required to ensure that these animals thrive in captivity. As it covers all the British toads, newts, snakes and lizards, it will be particularly valuable to those who organise school vivaria, and also to all naturalists whose interest leads them to collect and keep such animals. A good number of foreign species are included, and this coupled with the fact that the author deals very systematically with each species (giving details of distribution, external features, habits, hibernation, food and breeding) extends the range of readers who will find it useful. Workers in museums, research establishments and zoos concerned with keeping live specimens will find it a valuable compendium which gives a great deal of information which otherwise would be hard to track down because it is scattered in small fragments through so many publications.

The book devotes 34 pages to fish for cold-water aquaria, and there is a 22-page chapter dealing with the best types of plants to include in such aquaria; 'mixed' aquaria containing a variety of animal species can be maintained in a healthy condition for a much longer time than aquaria containing only one or two species, and this chapter includes all the data one needs in planning an aquarium in which the balance between the different kinds of animals will approximate to the natural balance existing in a typical natural pond.

Most of the species are described in sufficient detail for the descriptions to be used for identification purposes, and the many drawings by Humphrey Dakeyne are also helpful in this connexion.

Climatological Atlas of the British Isles prepared by Meteorological Office, Air Ministry (*London, H.M.S.O., 1952, 52s. 6d.*)

This atlas has been mainly compiled from records of thousands of observers in this country, as well as from Air Ministry records. Although delayed in preparation by the war its publication is a notable event, since this is a complete climatological atlas of the British Isles.

This atlas is superbly produced on fine paper, well printed and divided into ten sections, each of which is complete

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with an introductory part. All the maps and plates are bold and clear; the use of different colours for different elements is excellent in principle, but unfortunately in this case the plates for rain, snow and thunder are all very close shades of blue. The sunshine and fog and visibility plates are both a close salmon tint and reddish brown; perhaps a little more imaginative choice of colours for these sections from the wide range of pastel colours available would have been a little wiser, though one appreciates that this would have added a few shillings to the price of the book.

F. A. HENSON

Embryos and Ancestors by G. R. de Beer, F.R.S. (*London, Geoffrey Cumberlege, Oxford University Press. Revised Edition 1951, 159 pp., 15s.*)

Haeckel's theory of recapitulation, according to which the embryonic stages through which an animal develops reflect the evolution of its race, has bitten deep into elementary biological teaching. Modern knowledge does not fit in with this theory, and in this book (which first appeared in 1940 and which has been brought up to date and enlarged) Dr. de Beer, the present director of the Natural History Museum, produces a powerful indictment of the theory and shows how a better synthesis can be made of the facts of embryonic development and evolutionary descent which have been accumulated since Haeckel's time.

Classified Advertisements

OFFICIAL APPOINTMENTS

ASSISTANTS (SCIENTIFIC): The Civil Service Commissioners invite applications for pensionable posts. Applications may be accepted up to 31 December, 1953, but an earlier closing date may be announced either for the competition as a whole or in one or more subjects.

Age at least 17½ and under 26 years of age on 1 January, 1953, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted.

Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science subject and of thorough experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces, covering a minimum of two years in one of the following groups of scientific subjects:

(i) Engineering and physical sciences.
(ii) Chemistry, bio-chemistry and metallurgy.
(iii) Biological sciences.
(iv) General (including geology, meteorology, general work ranging over two or more groups (i) to (iii) and highly skilled work in laboratory crafts such as glass-blowing).

Salary according to age up to 25: £236 at 18 to £363 (men) or £330 (women) at 25 to £500 (men) or £417 (women); somewhat less in provinces. Opportunities for promotion.

Further particulars and application forms from Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.59/53. Application forms should be returned as soon as possible.

EXPERIMENTAL OFFICERS AND ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts. Applications may be accepted up to 31 December, 1953, but an earlier closing date may be announced either for the competition as a whole or in one or more subjects. Interviews will generally be held shortly after the receipt of the completed application form.

The posts are divided between following main groups and subjects (*a*) Mathematical and Physical Sciences, (*b*) Chemistry and Metallurgy, (*c*) Biological Sciences, (*d*) Engineering subjects and (*e*) Miscellaneous (including e.g. Geology, Library and Technical Information Services).

Age Limits: For Experimental Officers, at least 26 and under 31 on 31 December, 1953; for Assistant Experimental Officers at least 18 and under 28 on 31 December, 1953. Extension for regular service in H.M. Forces.

Candidates must have at least one of a number of specified qualifications. Examples are Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1953 may be admitted. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

Inclusive London salary scale:

Experimental Officer
£681–£838 (men); £586–£707 (women).
Assistant Experimental Officer
£274–£607 (men); £274–£511 (women).

Starting pay according to age up to 26. At 18, £274; at 26, £495 (men); £467 (women). Somewhat lower in provinces.

Further particulars and application forms from Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S94–95/53. Completed application forms should be returned as soon as possible.

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG
South Africa

APPLICATIONS are invited for a SENIOR LECTURESHIP IN GEOLOGY. Applicants should have specialised either in Stratigraphy and Palaeontology, or in Economic or Mining Geology.

The salary attached to the post is on the scale £800 × 40–£1000 together with a temporary cost-of-living allowance which at present is £272 p.a. for a married man or a man with dependants, and £176 p.a. for others. The University anticipates a substantial improvement in basic salaries, and pending the outcome of the report of a Government Commission on University finance, the University has been enabled to pay a special non-pensionable allowance at the rate of £75 p.a.

Further particulars and information as to the method of application may be obtained from The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1. The closing date for the receipt of applications is 31 July, 1953.

AUCKLAND UNIVERSITY COLLEGE
(University of New Zealand)

APPLICATIONS are invited for a LECTURESHIP IN PREHISTORY (in the Department of Anthropology).

Qualifications in other branches of anthropological science (and particularly in Physical Anthropology) will be taken into account in selecting the Lecturer.

Salary will be at the rate of £800 per annum rising to £950 per annum, by annual increments of £50. Allowance is made for travelling expenses. Further particulars and information as to the method of application may be obtained from The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1. The closing date for the receipt of applications in New Zealand and the United Kingdom is 31 August, 1953.

CROWN AGENTS FOR THE COLONIES

SCIENTIFIC ASSISTANT required for service in Antarctic with the Falkland Islands Dependencies Survey for tour of 18 or 30 months in first instance. Salary according to age and qualifications in scale £400 rising to £540 a year. Free quarters, food, clothing and canteen stores provided enabling officer to save most of his salary. Free passage. Liberal leave on full salary. Candidates must be of good education with good knowledge of physics and radio maintenance. Selected candidate will undergo three months' course in IONOSPHERIC work before sailing. Apply in writing to the Crown Agents, 4 Millbank, London, S.W.1, stating age, name in block letters, full qualifications and experience and quoting M3B/33763/DI.

OXFORD UNIVERSITY DELEGACY FOR EXTRA-MURAL STUDIES: Extension Lectures Committee. Applications are invited for the post of Extension Lecturer in Science. Applicants should have special qualifications in Natural Science (preferably Biology) together with appropriate experience in adult education and should be prepared to conduct courses in any part of the Oxford Extra-Mural area. Salary £550 × £25 to £650, thereafter × £50 to £900, initial salary being determined according to qualifications and experience. Child allowances are payable and the successful candidate will be expected to enter the Federated Superannuation System for Universities. Forms of application and further particulars may be obtained from the Secretary, University Extension Lectures Committee, Rewley House, Wellington Square, Oxford, to whom completed applications should be returned by 15 July, 1953.

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